Machine Detector Interface

Toshiaki Tauchi (KEK) for the MDI-CTG and BDS

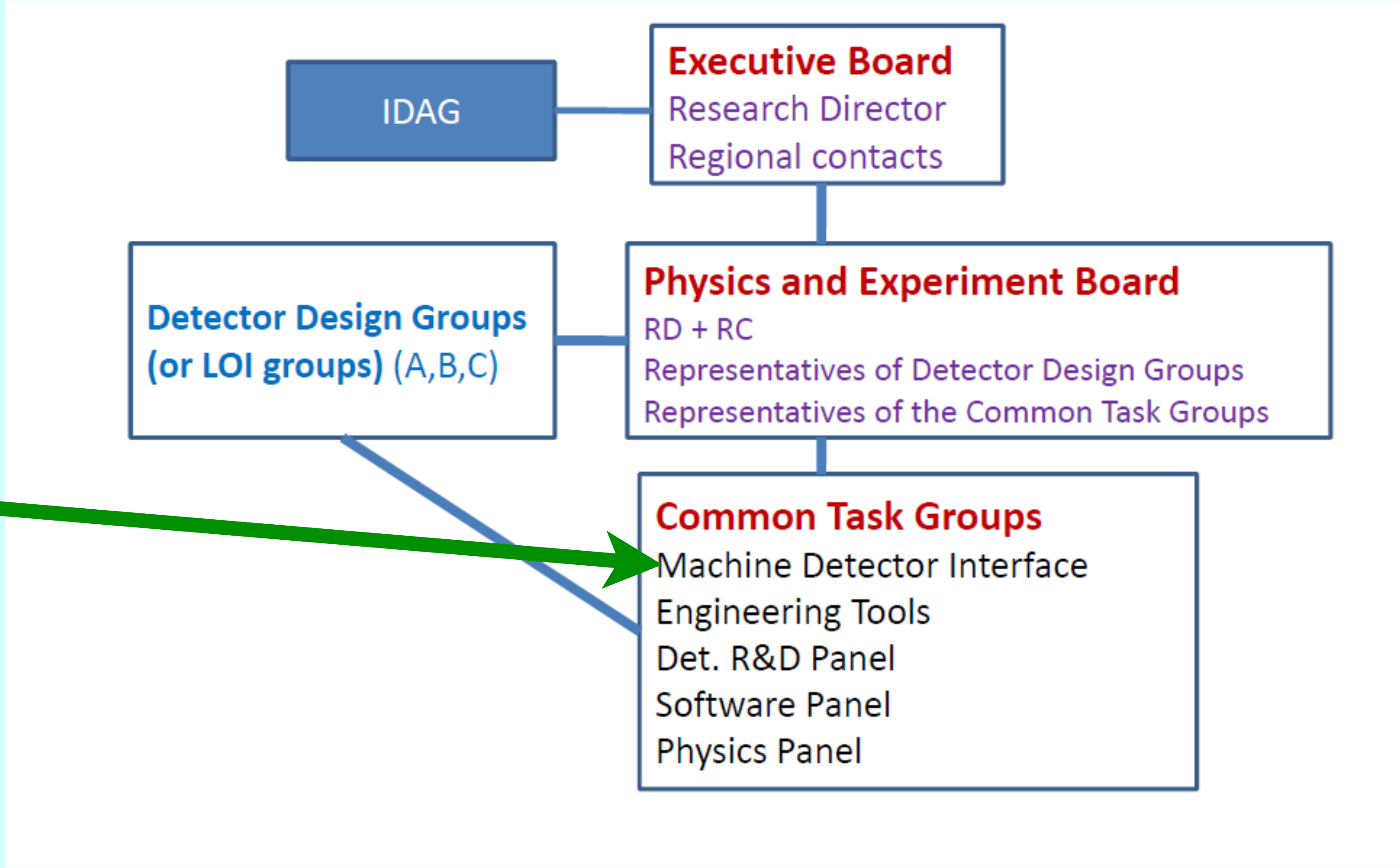
ILC Project Advisory Committee

Academia Sinica, Taipei, Taiwan

19-20 May 2011

The MDI Common Task Group

- Common task group of the Research Director's organisation:



- Members:
  - K. Buesser (DESY, convener)
  - P. Burrows (Oxford, dep. convener)
  - A. Hervé (ETH Zürich)
  - T. Markiewicz (SLAC)
  - M. Oriunno (SLAC)
  - T. Tauchi (KEK)
- Usually meets in phone meetings (~ monthly)
- Close contact to the GDE BDS group
  - A. Seryi participates regularly in the phone meetings

IR Interface Document : before down-selection of detectors by IDAG:

Functional Requirements on the Design of the Detectors and the Interaction Region of an e+e- Linear Collider with a Push-Pull Arrangement of Detectors, March 2009, by the MDI and BDS contact persons

QD0 Support and Alignment as an example for specifications

Given variations in floor height under load and with time it is assumed that each detector will have a large range but coarse means (shims, jacks, etc.) of bringing the QD0 cryostat to a position close enough to the QF1(e+)-QF1(e-) defined beamline that a finer resolution limited range alignment system can bring the cryostat to its final pre-beam position. Seemingly reasonable working values are

- Detector axis alignment accuracy: ± 1 mm and 100 μrad from a line determined by QF1s
- Detector height adjustment range: +/- several cm, to be determined after site selection and geologic study

A detector mounted alignment system for QD0 (functionally equivalent to the eccentric cam based mover system [7] developed for the FFTB and LCLS and used as well at ATF2) should fufill the following requirements:

- Number of degrees of freedom: 5 (horizontal x, vertical y, roll α, pitch ϕ, yaw ψ)
- Range per x,y degree of freedom: ± 2mm
- Range per α,ϕ,ψ degrees of freedom: ± 30 mrad (roll), **±**1 mrad (pitch and yaw)
- Step size per degree of freedom of motion: 0.05 μm

Before low intensity beams are allowed to pass through QD0 for high precision beam-based alignment, the mechanical mover system will be required to bring QD0 into alignment with an

- Accuracy per x,y degree of freedom: ± 50 μm
- Accuracy per α,ϕ,ψ degree of freedom: ±20 mrad (roll), ± 20 μrad (pitch and yaw)

The QD0 mechanical alignment accuracy and stability after beam-based alignment and the QD0 vibration stability requirement are set by the capture range and response characteristics [8] of the inter-bunch feedback system.

- QD0 alignment accuracy: ± 200 nm and 0.1 μrad from a line determined by QF1s, stable over the 200ms time interval between bunch trains
- QD0 vibration stability: Δ(QD0(e+)-QD0(e-)) < 50 nm within 1ms long bunch train

For DBD/TDR : Design Study for the Interaction Region; Push-Pull System for the ILC

by the MDI-CTG + A.Seryi (BDS) , July 2010

Tasks (Work Plan)

The following list summarises the major tasks of the working plan.

1. Design of the detector motion system; study of its vibration properties in simulation and experiment.
2. Design of the IR underground hall for push-pull, including facilities and services for the operation of the detectors, radiation shields, seismic issues, impact of safety rules.
3. Optimisation of the detector integration and its impact on assembly procedures, magnetic and radiation shielding, vibration sources.
4. Design of detector services supplies for push-pull (data and HV cables, cryogenics).
5. Design and prototype of the final doublet quadrupoles and verification of their stability.
6. Design of alignment system for the final doublet magnets and the inner detector components, including the design of a laser interferometer system.
7. Study on IR vacuum design, including vacuum requirements and design of quick connection valves.
8. Study of intra-train feedback systems in a push-pull system.

Table 1 Milestones

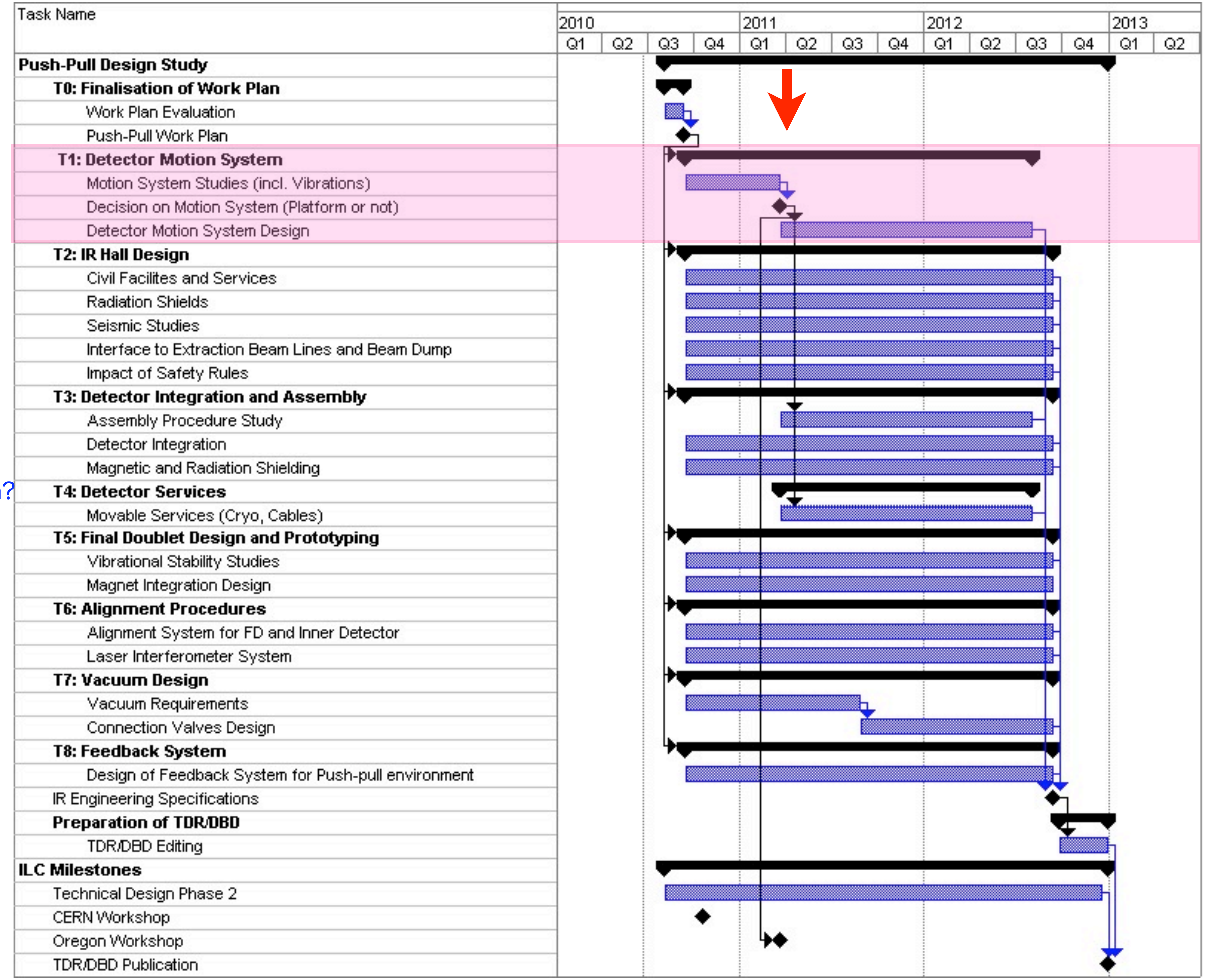
Date	Milestone
Summer 2010	Finalisation of work plan, implementation of additional resources
October 2010	Linear Collider Workshop at CERN
March 2011	Linear Collider Workshop (ALCPG11) , Eugene
Spring 2011	First draft of IR engineering specifications
Fall 2012	Finalisation of IR engineering specifications
End of 2012	Finalisation of ILC Technical Design Report and the Detailed Baseline Description

Work Plan Diagram

Done

common?

draft



Participants and Resources (1)

Participant	Task Nos.	Description of work	Commitment (FTE)	Additional Request (FTE)
CERN	1, 2, 3, 4	Hall design, detector services, push-pull motion system, movable detector services supplies	0.0	2 (official) very appreciated
ETH Zurich	1, 2, 3, 4	Hall design, detector services, push-pull motion system, movable detector services supplies	1.0	0.0
DESY	1, 2, 3	Hall design, push-pull motion system, radiation shields, magnetic shielding	1.0	0.0
KEK	1, 2, 3	Hall design, Vibration studies, detector integration, radiation shielding, Mountainous (Mtn.) site study	0.4	1.5*
LAL	3, 7	Detector integration, vacuum studies	0.4	0.0
LLR	3, 7	Detector integration, beam pipe design	0.25	0.5
JAI	6, 8	Laser interferometer studies, intra-train feedback system, design integration	1	2

Participants and Resources (2)

Participant	Task Nos.	Description of work	Commitment (FTE)	Additional Request (FTE)
SLAC	1, 2, 3, 6	Beam pipe and VTX support, push-pull motion system, alignment, rad. physics	0.4	1.5 → 1.0 but -0.25
FNAL	2	Push-pull IR CFS integration	1.5	1.5
BARC	2	Push-pull IR to extraction and dump line interface	1.0	1.0
CI & ASTEC	7	Vacuum design for push-pull IR	0.5	1.0
JINR	2	Push-pull IR at shallow site	0.5	1.5
BNL	5, 6	Magnet design integration for push-pull IR	1.0	1.0
LAPP	2, 3, 6	FD & Detector stability	0.3	1.0
		Total	9.25	14.5 → 4.5 but -0.25

Plenary summery talk on “Planning the Push-Pull”

Conclusions by Marco Oriunno at ALCPG11

- Platforms are a technically acceptable solutions for the push pull, which preserves the respective design of the detectors and does not amplify the ground vibrations.
- The platforms must be designed according to a set of Functional Requirements, specifying the static and dynamic performances. These requirements will be defined by the detectors.
- The design and construction of the platforms becomes a task of the CFS group, which will develop the project along the requirements list and together with the detectors.

Plenary summery talk on “Planning the Push-Pull”

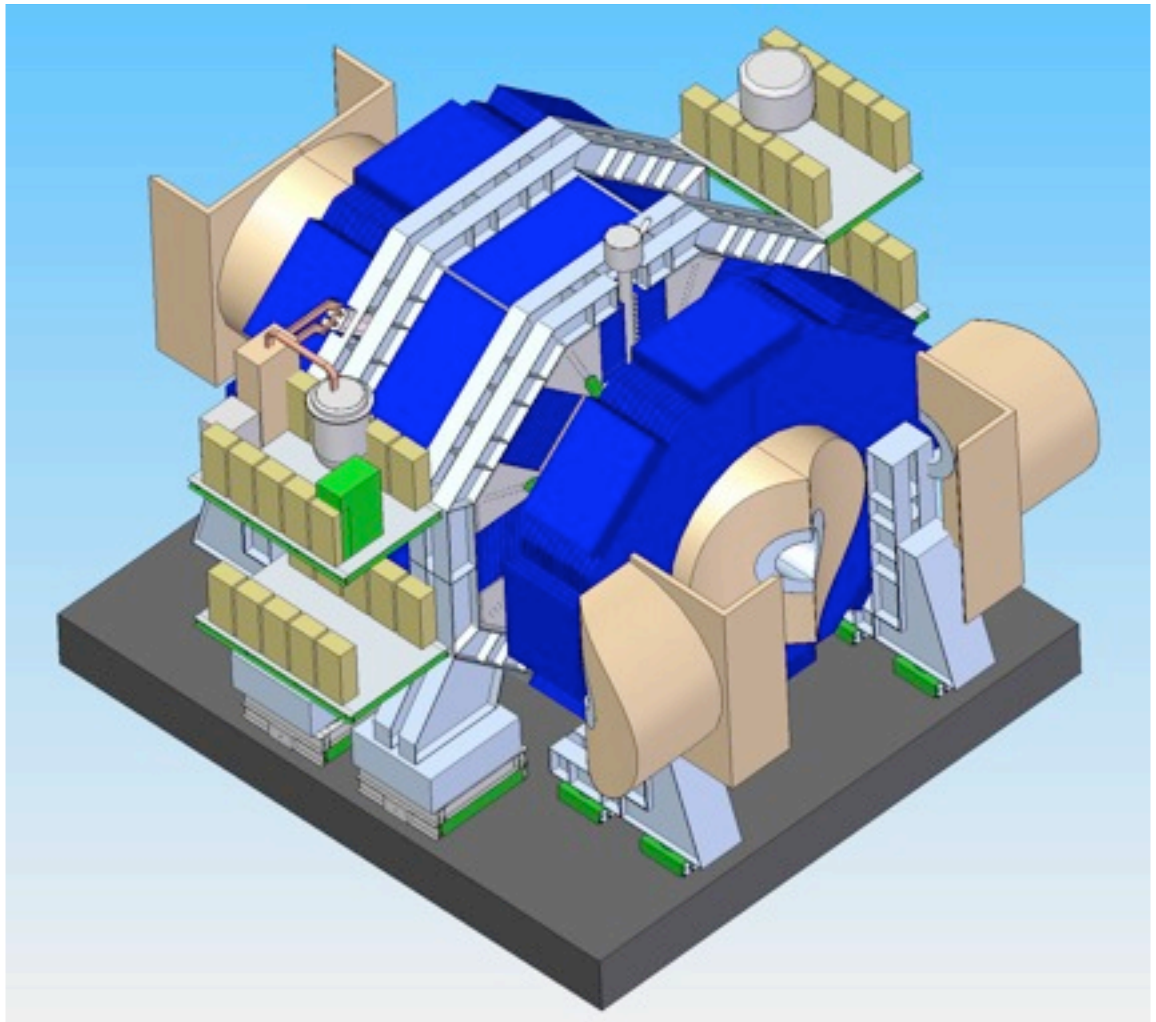
The work ahead

by Marco Oriunno at ALCPG11

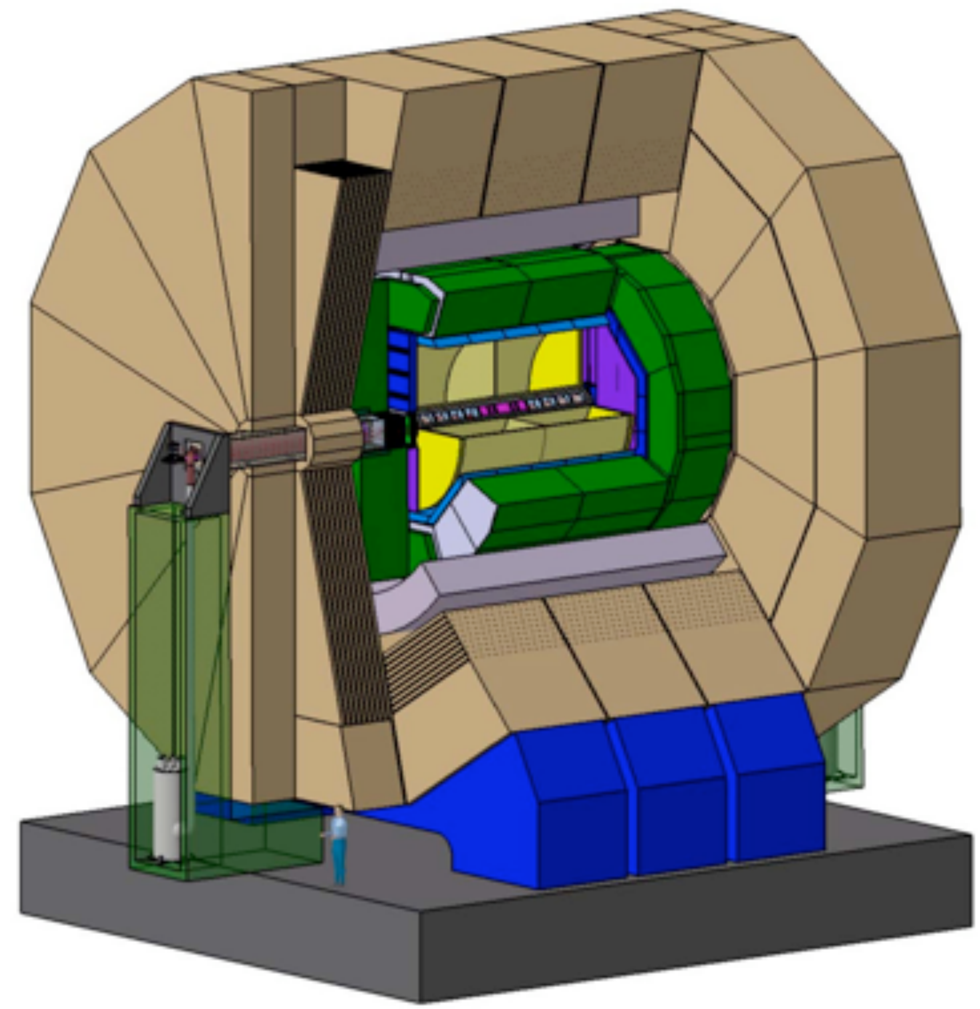
- The effects of vibrations on beam stability remain a subject which need further studies.
- Benchmarking of the FEM and experimental data is in progress : good results so far
- Start the optimization of the Experimental Area, integration of the platforms
- Decide on a Push-pull mechanism : Rollers, Air-pads, hydraulic jacks, etc.
- All above only achievable as common task MDI / CFS

Trade off study - Conclusion

by Marco Oriunno at ALCPG11



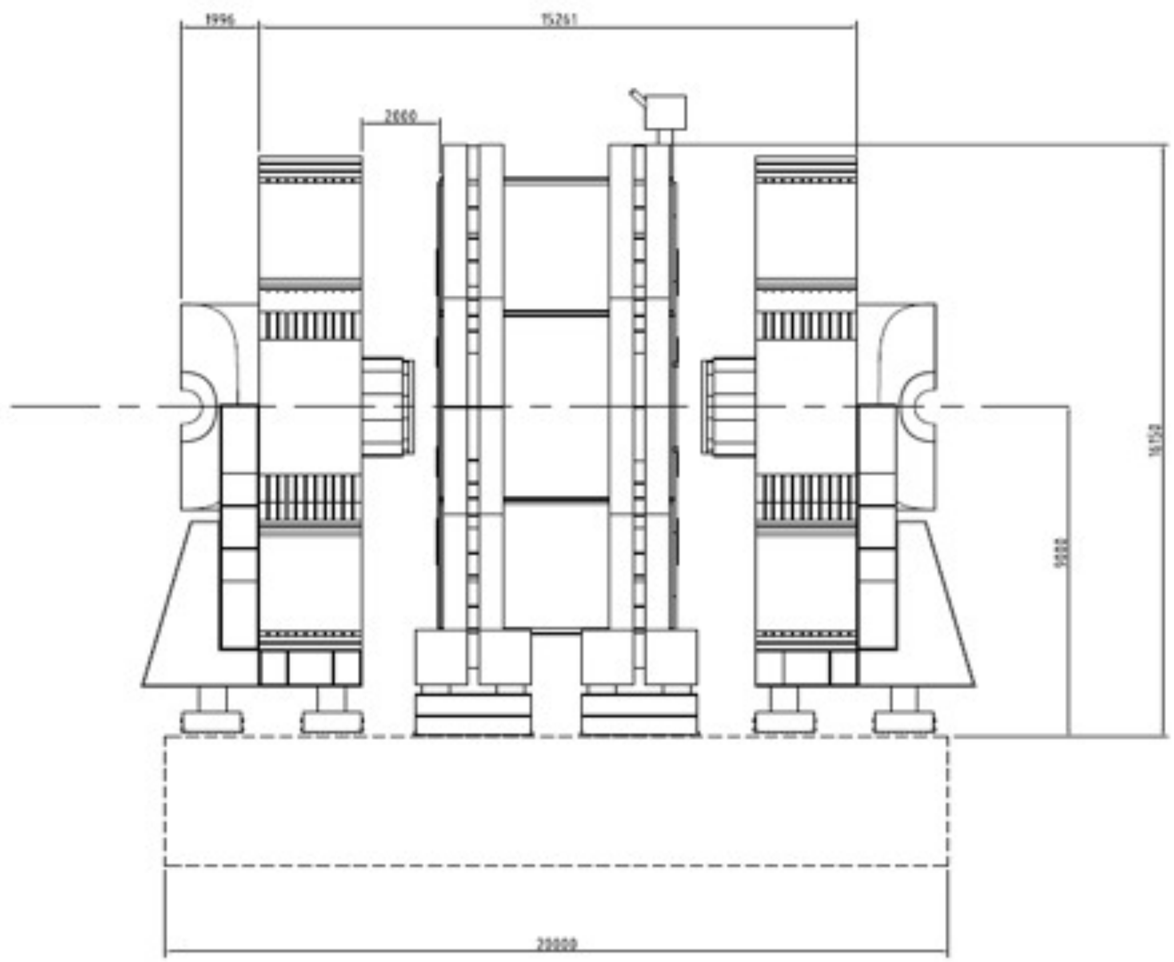
SiD with Platform

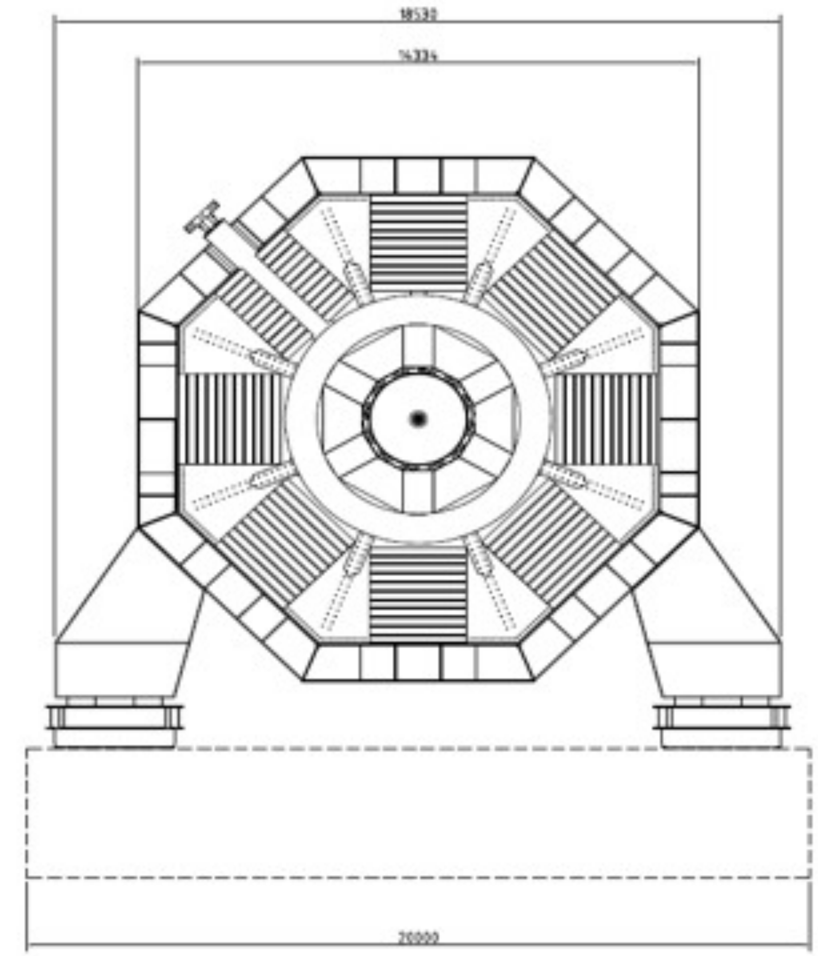


ILD with Platform

Mandatory requirements	SiD	ILD
Design Change Impact	None	None
Vibrations Amplification	Low	Low

SiD Platform Functional Requirements





SiD nominal mass: Barrel   5000 T; (each) Door 2500 T

Dimensions:

- Z = 20.0 m
- X = 20.0 m
- Delta Y = 9 m (Top of Platform to beamline)

Positioning Tolerance on beamline

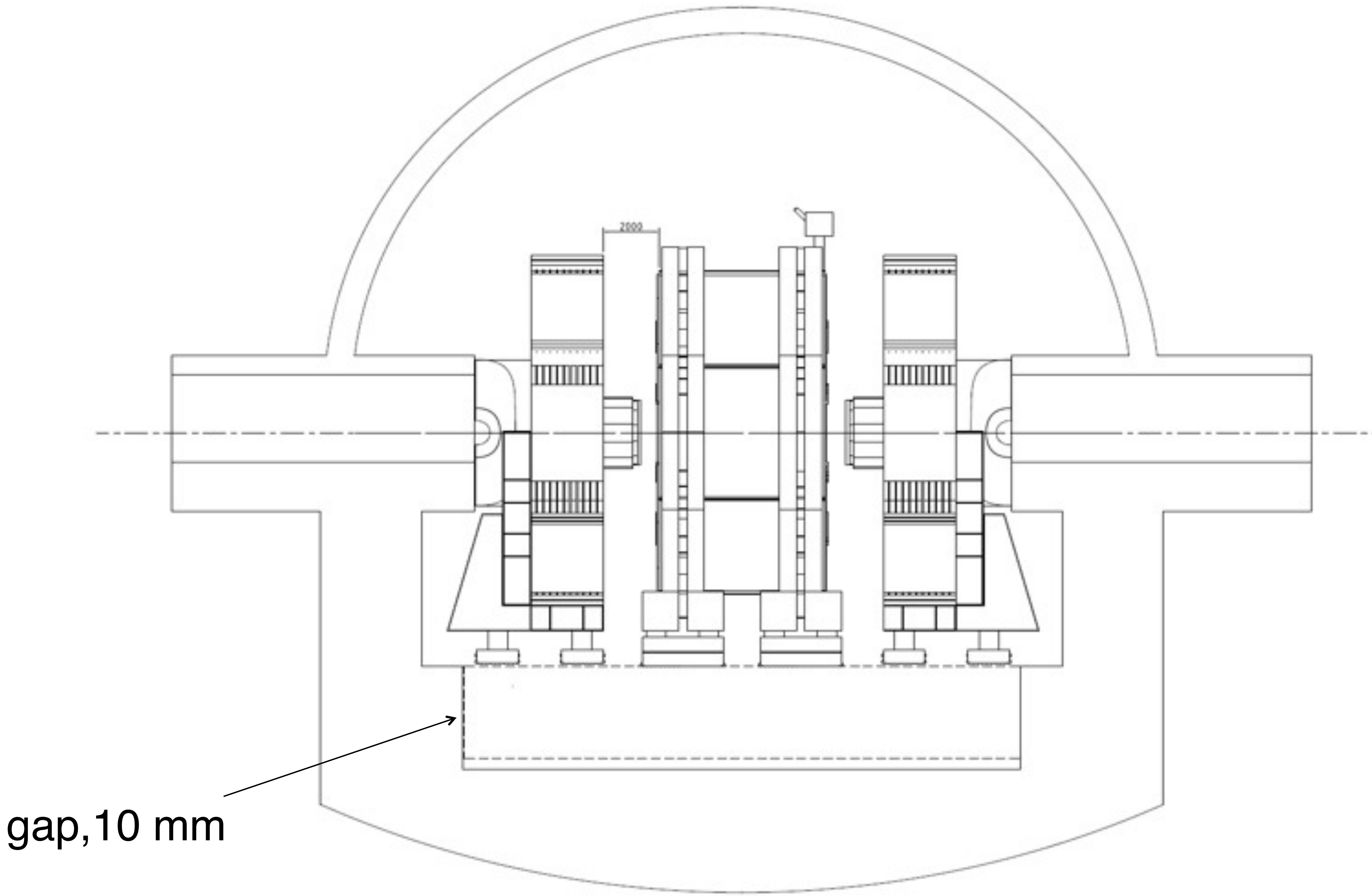
- Consider points Z=+-max, X=0. Position to + 1mm wrt references in X,Y,Z
- Consider points Z=+-max, X=+-max: Position to +- 1 wrt references in Y.

Static Deformations: <+-2 mm

Vibration Transfer Function from ground : Amplification < 1.5 between 1 and 100 Hz.

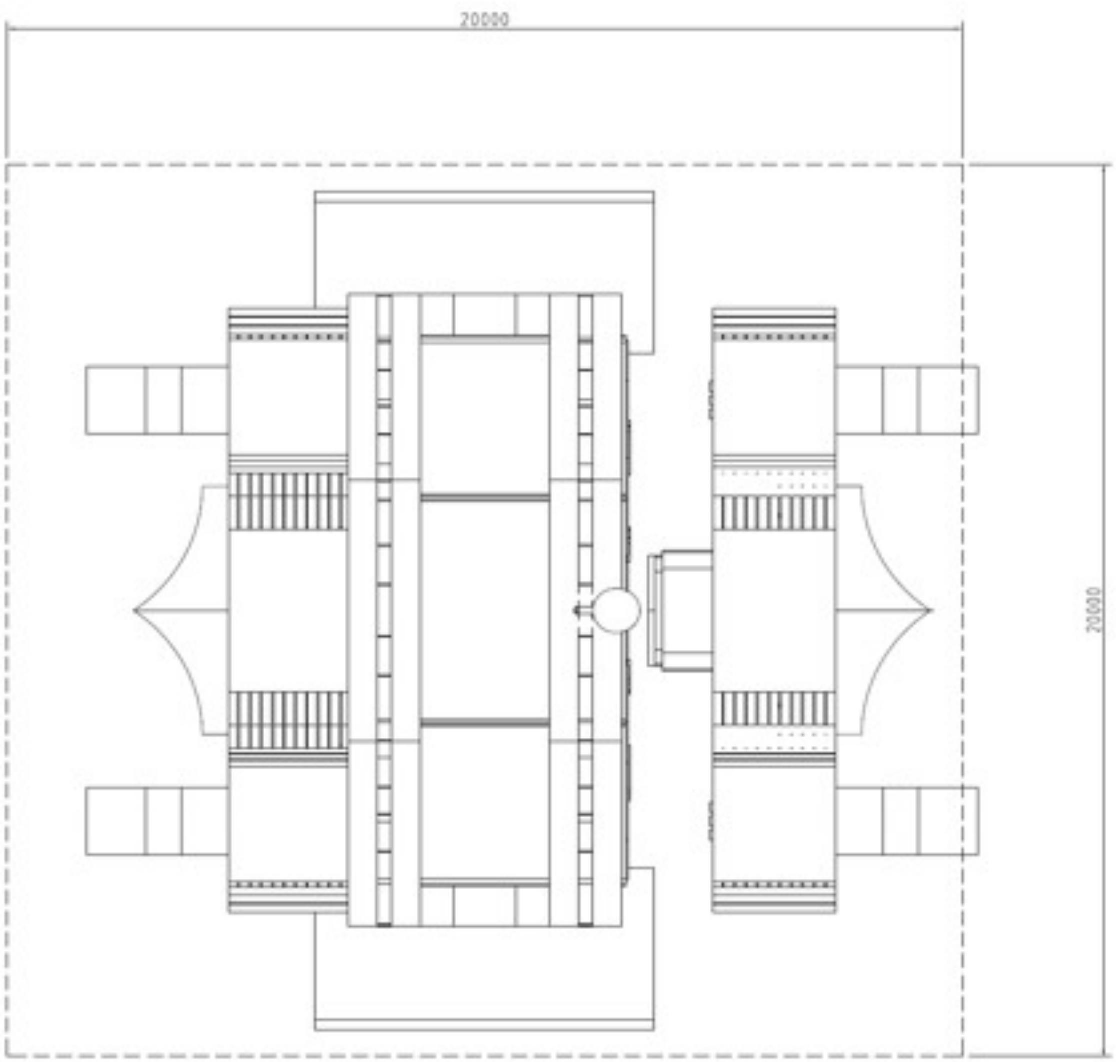
Seismic stability: Appropriate for selected site. (Beamline must be designed with sufficient compliance that VXD will survive)

SiD Platform Functional Requirements

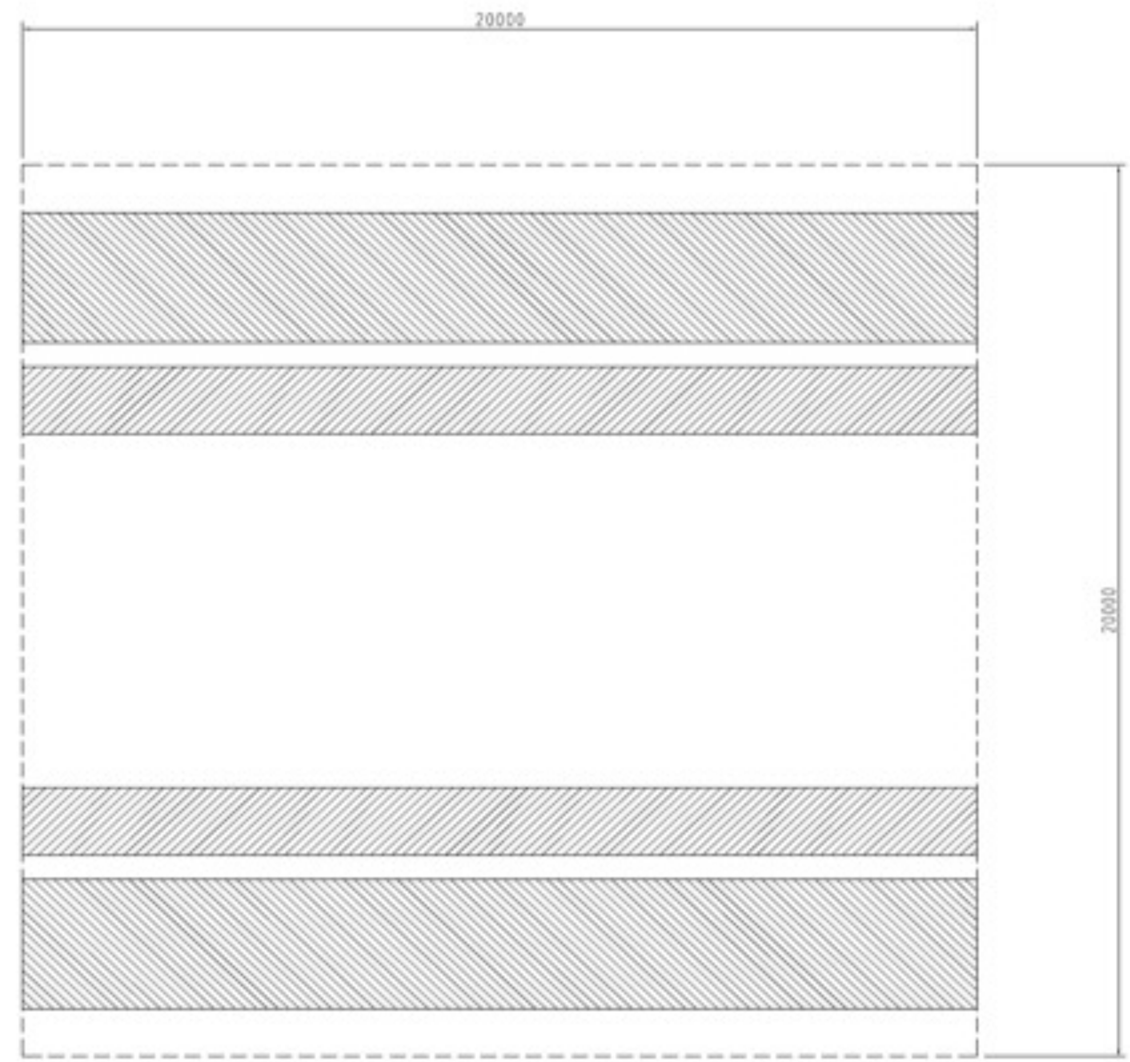


Wall clearance ~10 mm. Platform comes to side wall, there is no apron or apron matches platform elevation.

SiD Platform Functional Requirements



Detector Top View

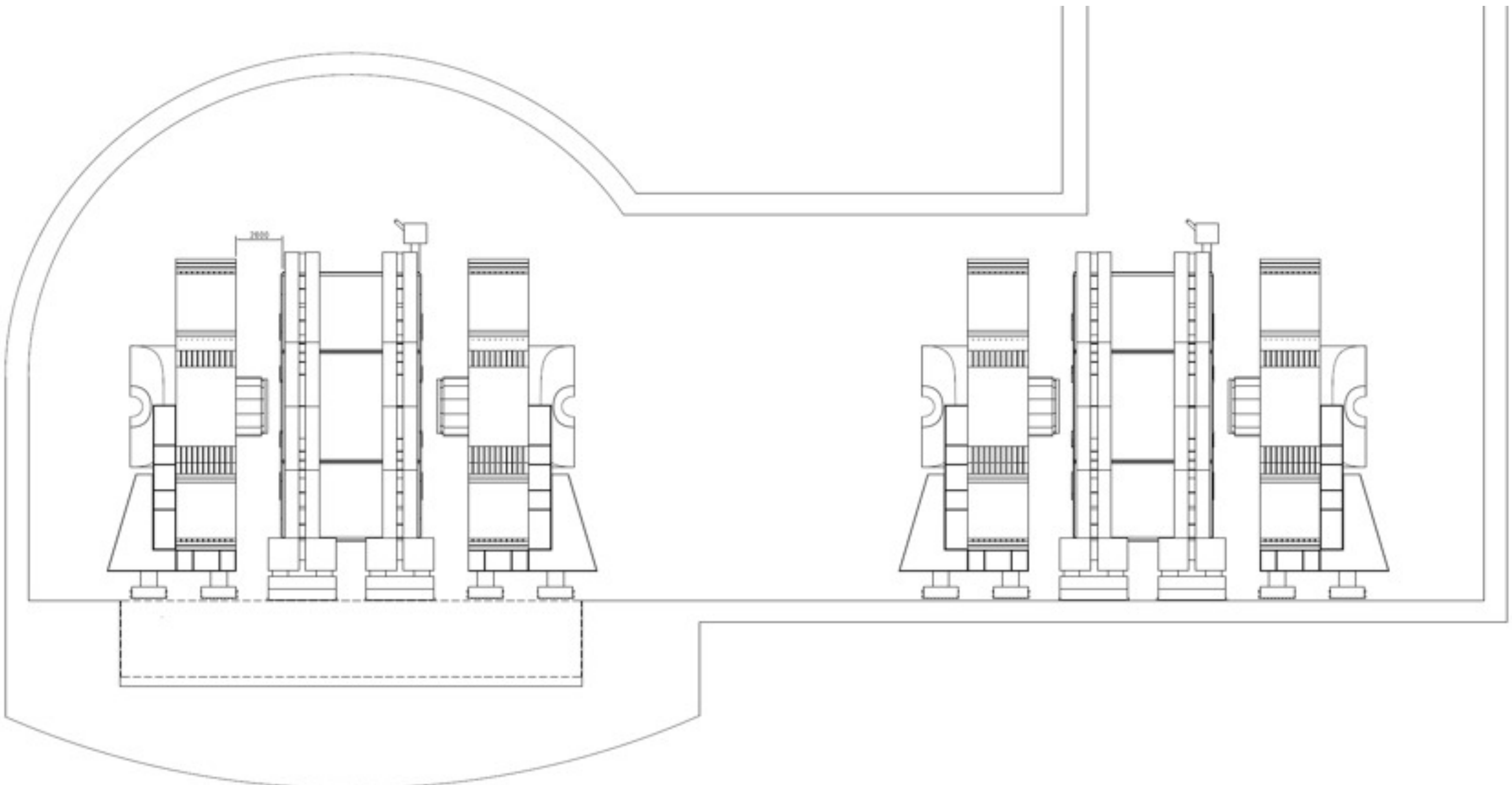


Platform Top View

Surface Features:

- Steel Surface near legs
- Steel rails for doors
- “Receptacles” for tie seismic tiedowns of SiD Barrel and Doors
- Removable Safety railings

SiD Platform Functional Requirements



Accelerations: <1 mm/s^2

Transport velocity: V>1 mm/s after acceleration

Life: 100 motion cycles.

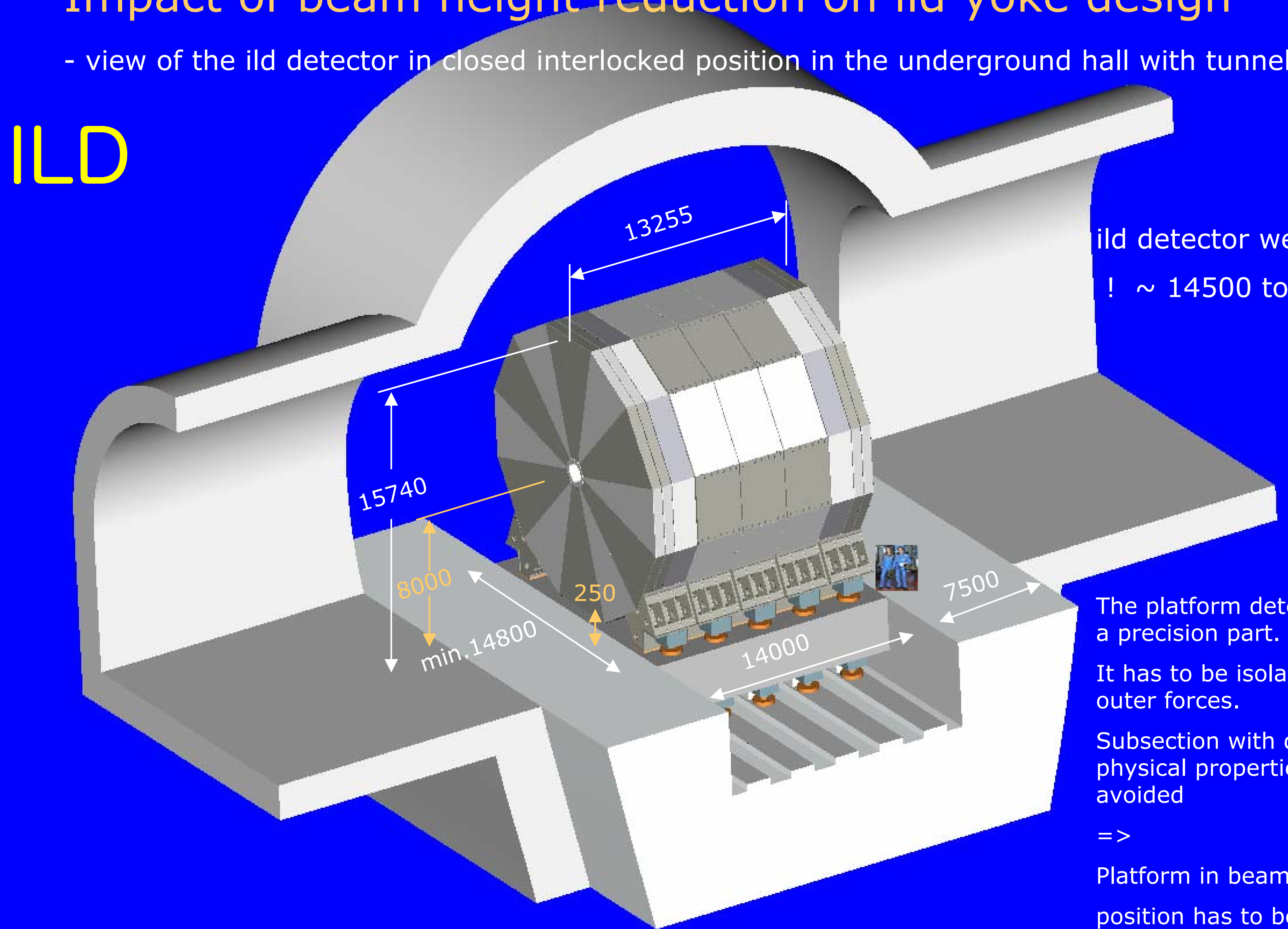
Reliability: Transport modularity must be such that repairs/ replacement/maintenance can be accomplished in garage position and within 20 elapsed days.

Any equipment required for transport shall reside below the platform surface.

Transport equipment shall not eject particulates that reach platform surface (need spec on how much)

Impact of beam height reduction on ild yoke design

- view of the ild detector in closed interlocked position in the underground hall with tunnel



ild detector weight

! ~ 14500 tons

The platform detector unit is a precision part.

It has to be isolated from outer forces.

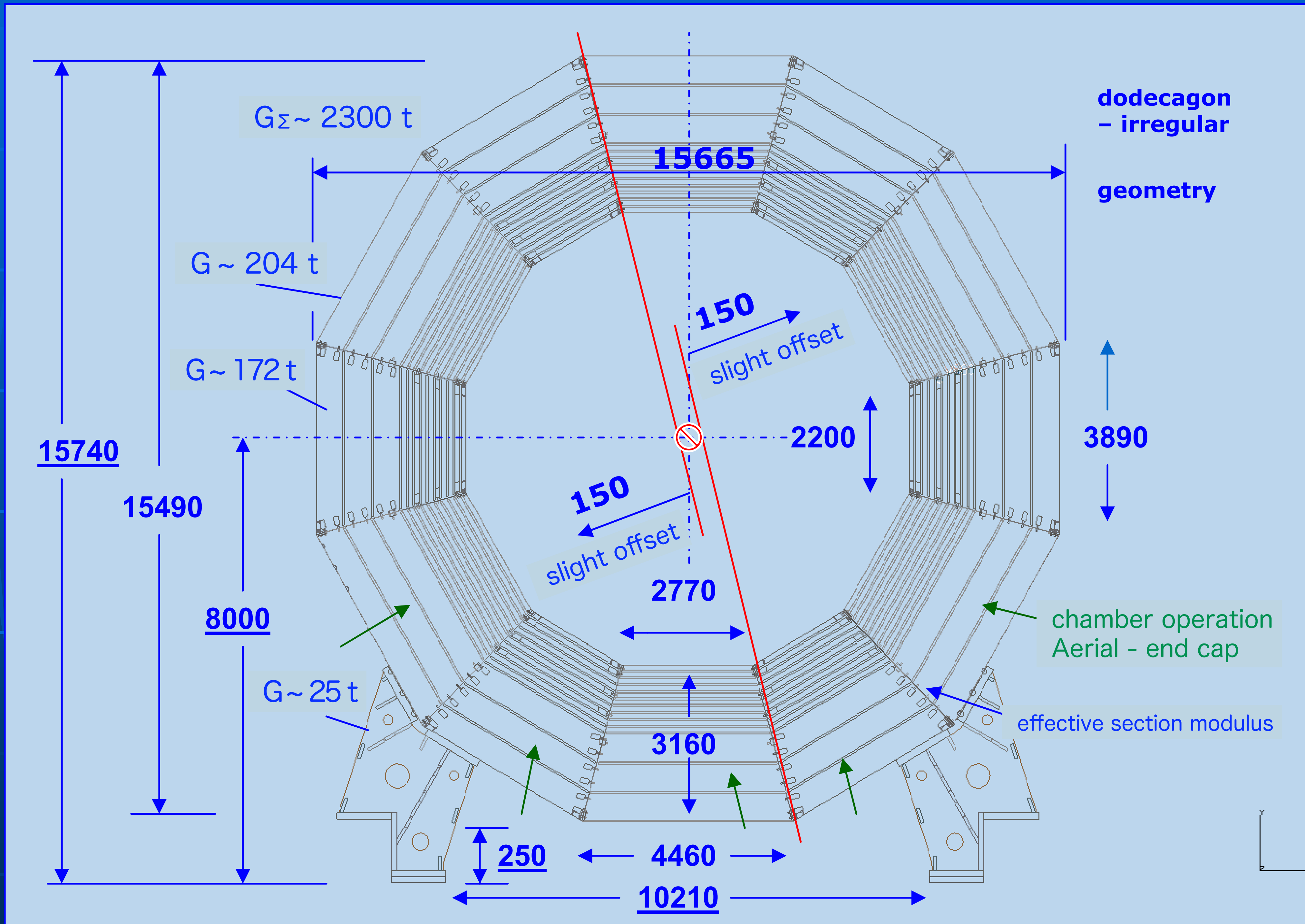
Subsection with different physical properties are to be avoided

=>

Platform in beam position has to be locked.

2011年 5月 20日 金曜日

barrel geometry / dodecagon have irregularly geometry - slight offset 150mm



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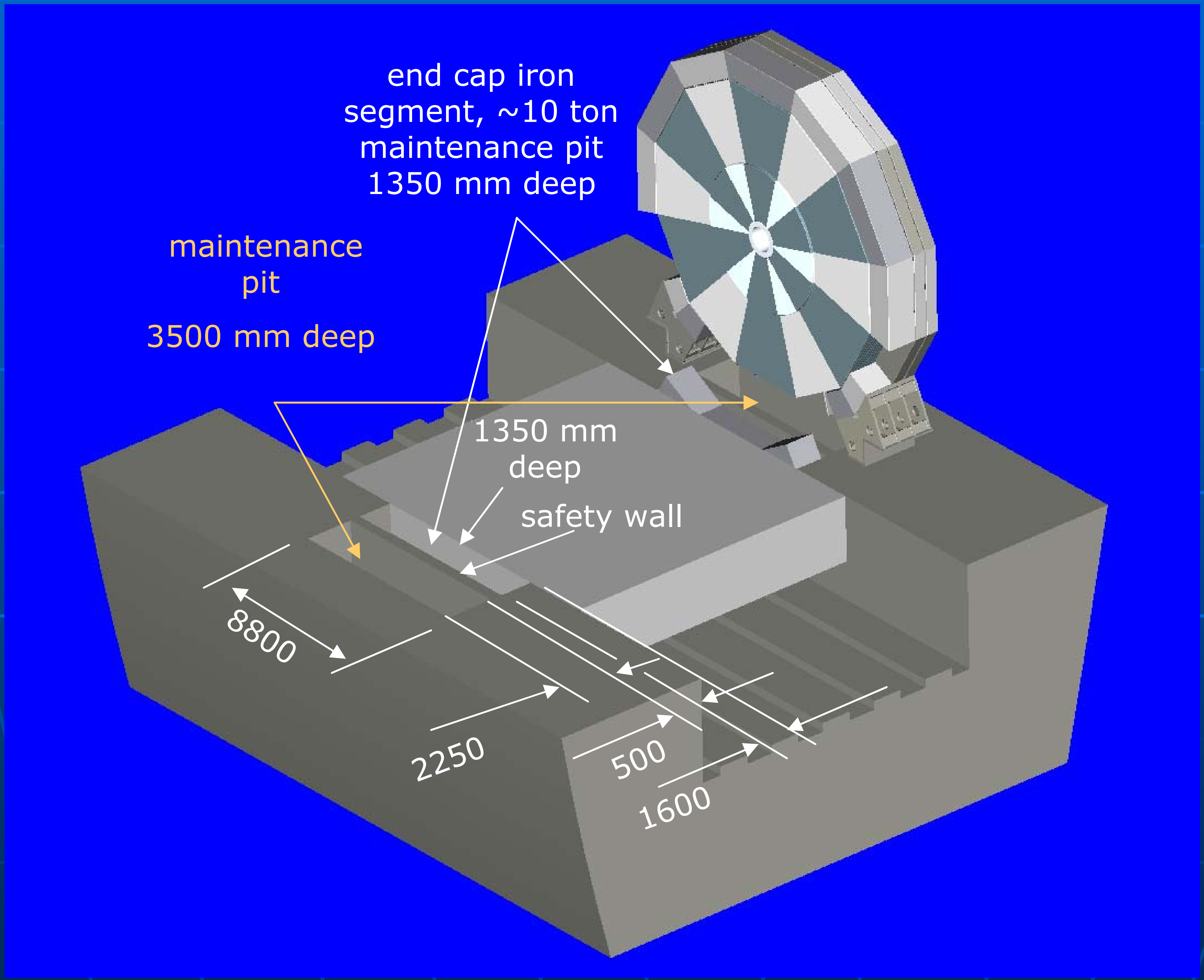
2011年 5月 20日 金曜日

ILD platform and hall fundament



End cape iron segment in low-angle shot:

automation operating be hydraulic cylinder, electric motor or lifting jack

All other segments positioning with hall crane

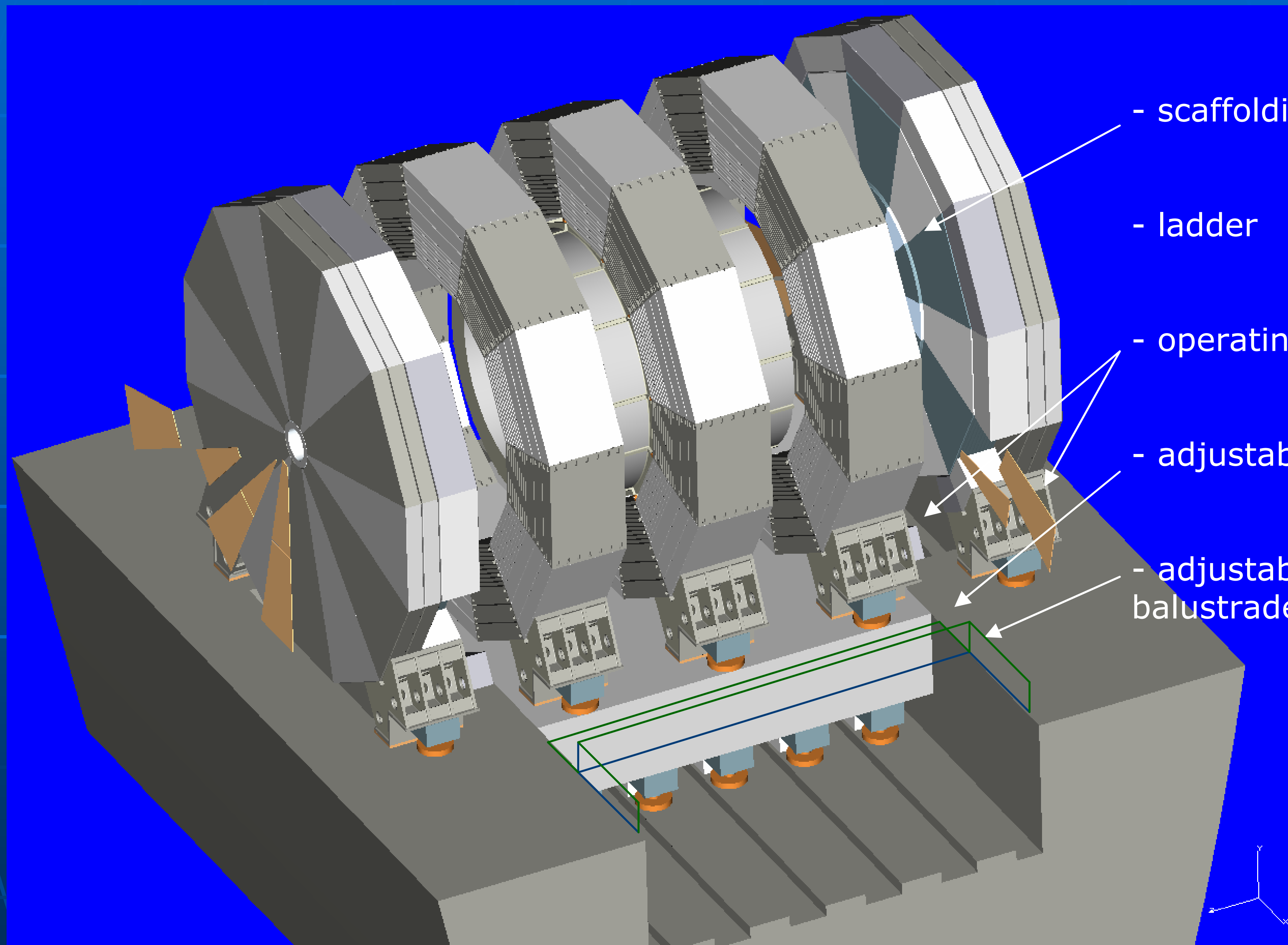
chamber pit:

manual with scaffold and leader

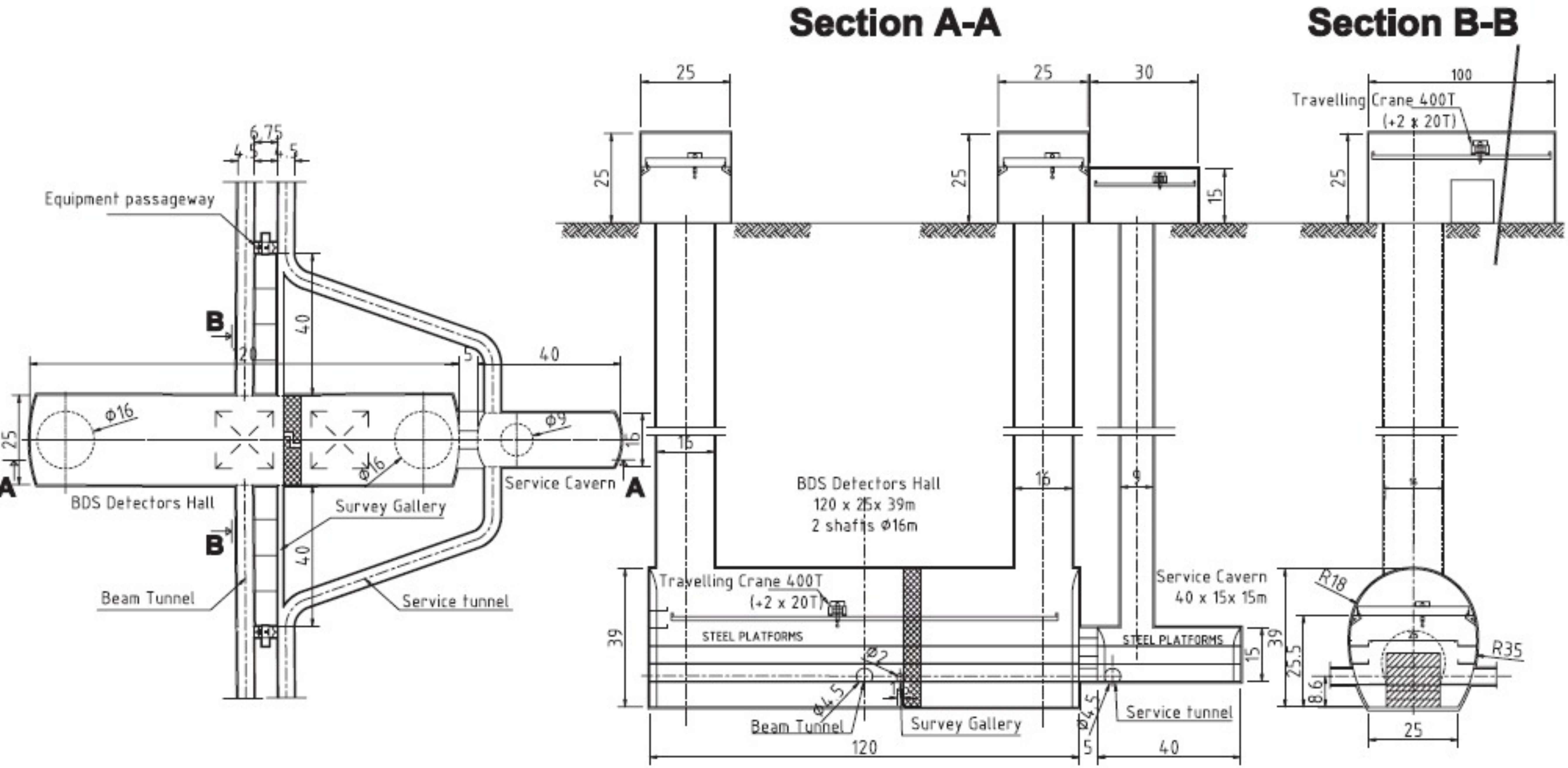
Platform is positioned and safety lock is applied

ILD

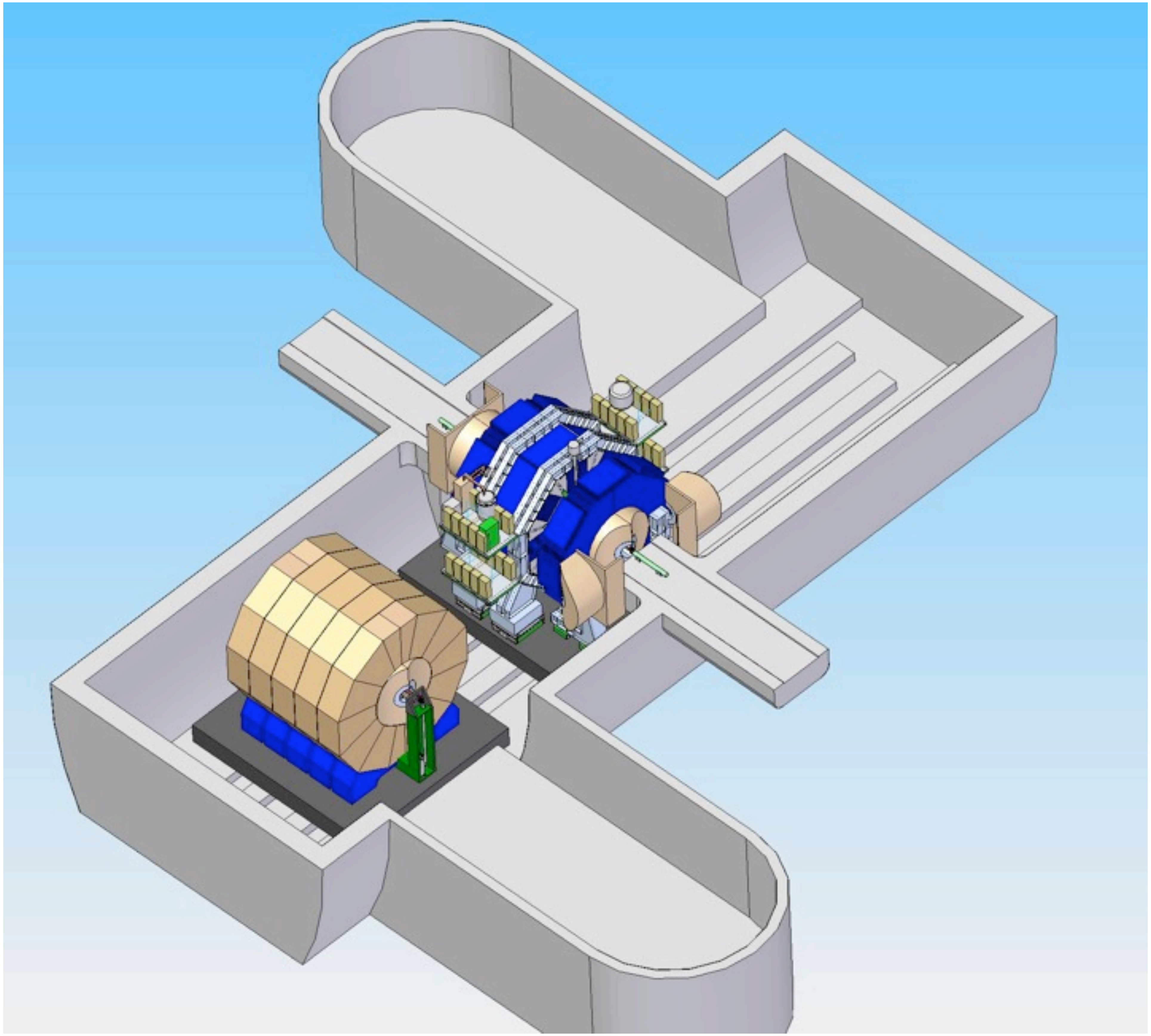
Overview of shut down



RDR Detector Hall Design



Platform Solution



by Marco Oriunno at ALCPG11

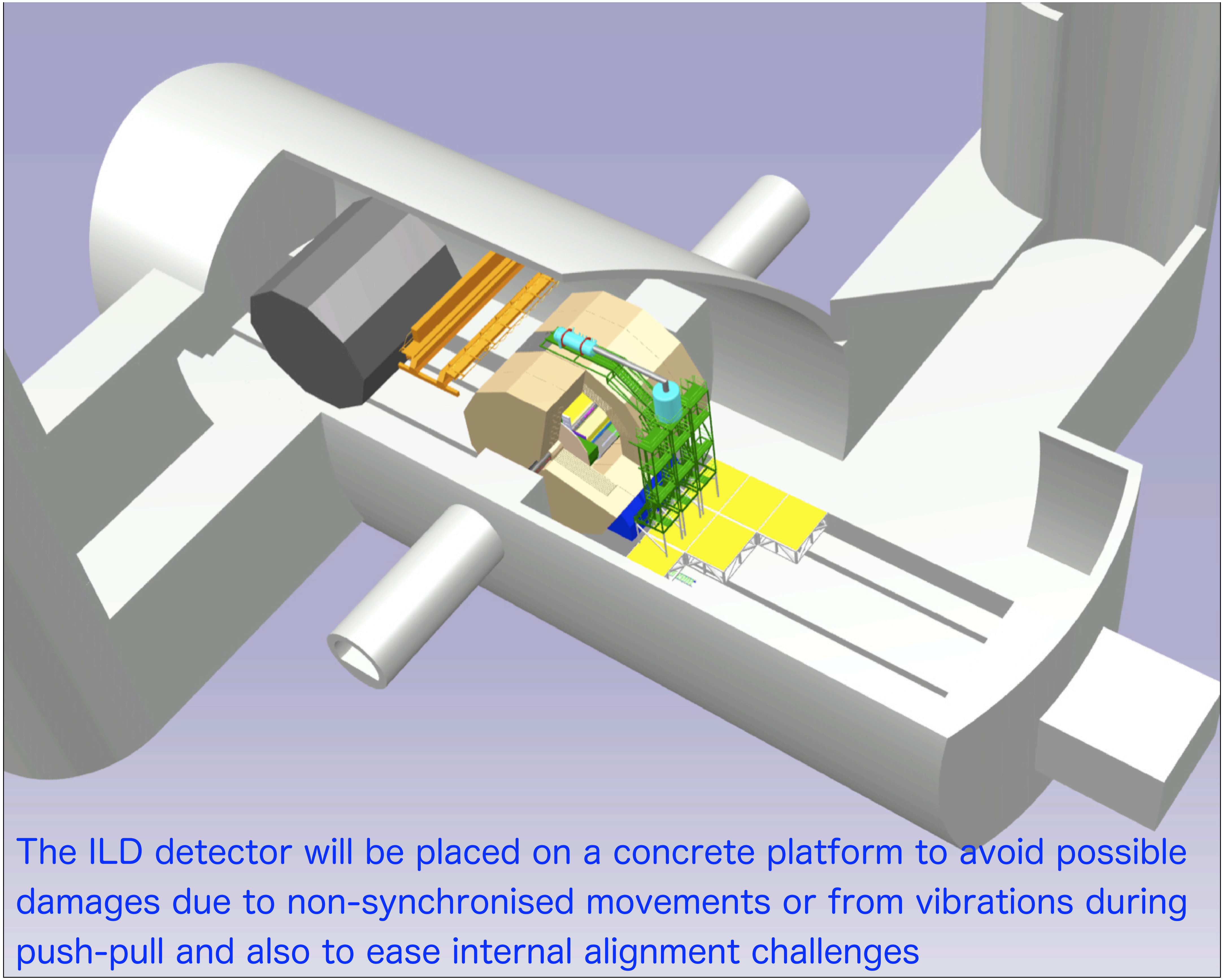
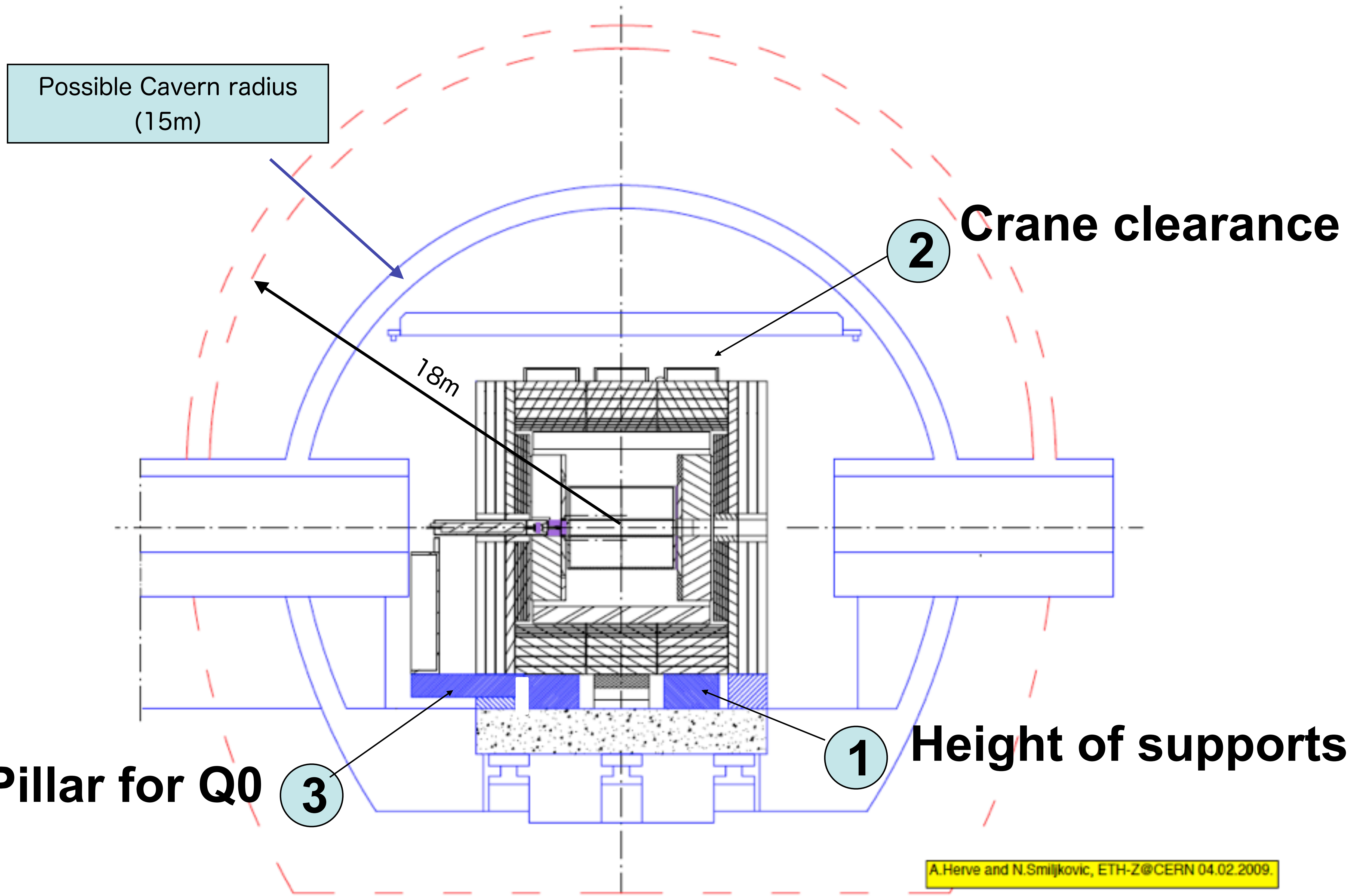
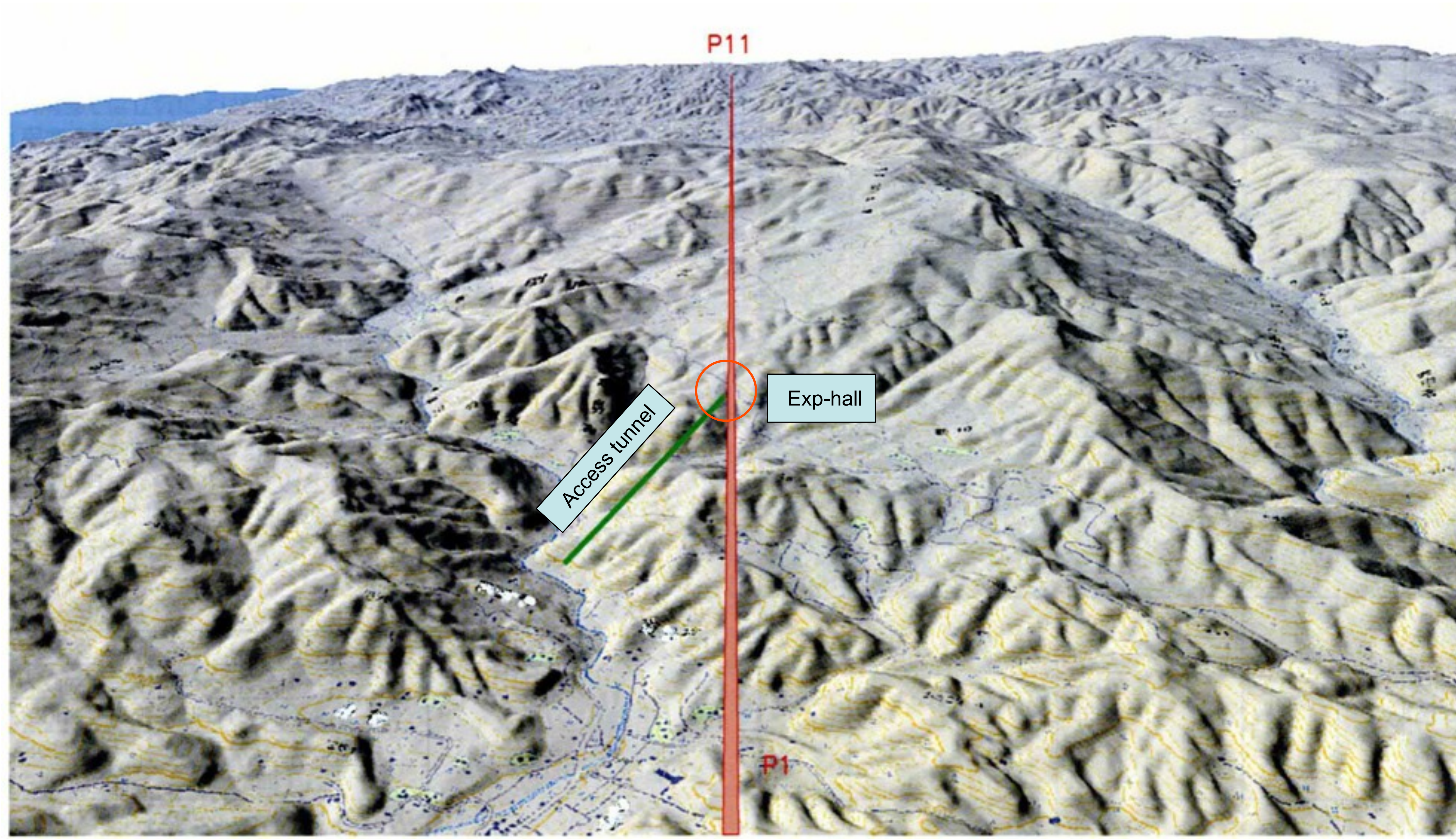


FIGURE 6.3-4. Design study of the underground experiment hall with ILD (left) and the second detector in push-pull configuration.

We have played on three parameters to try to reduce hall diameter

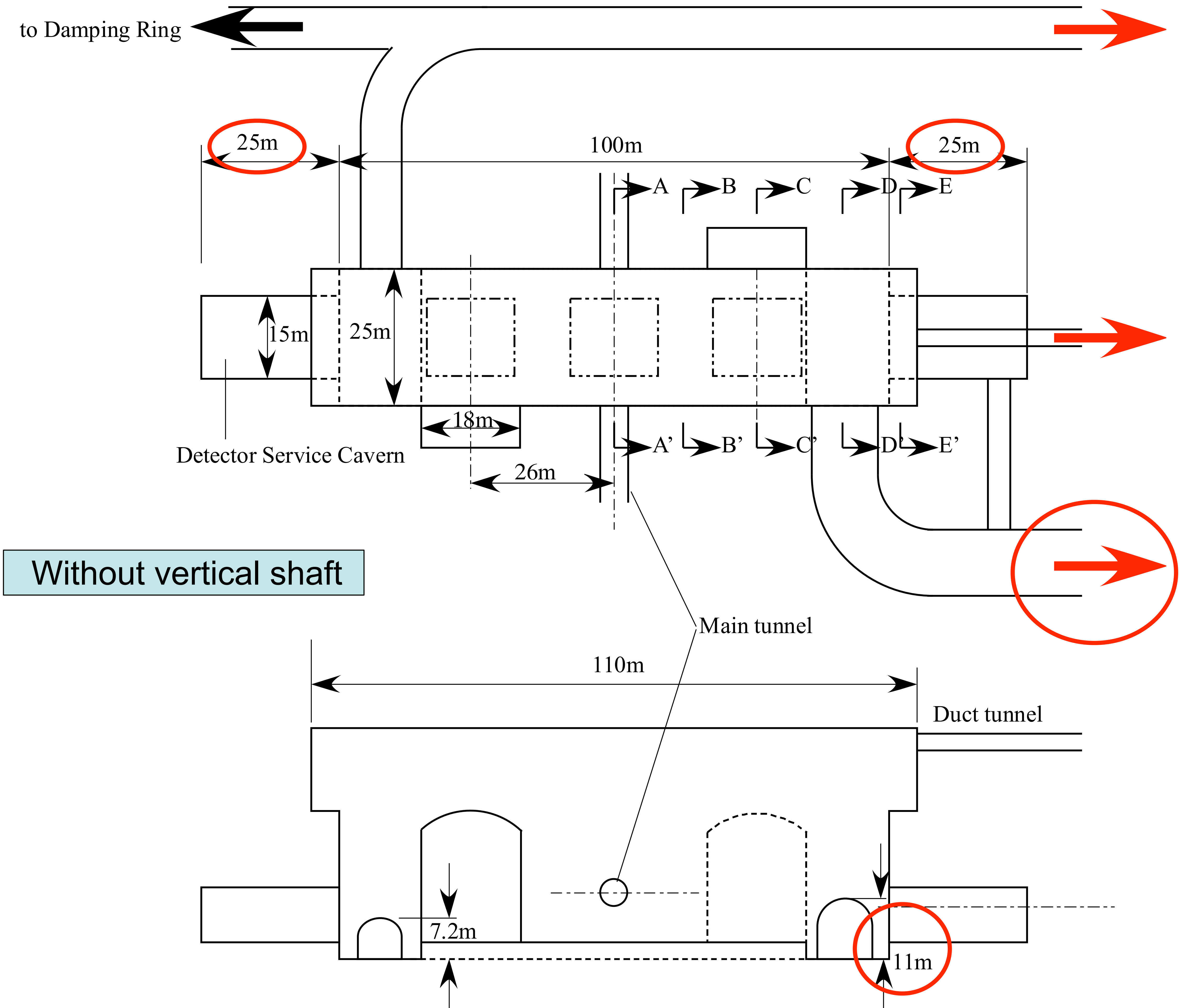


An example of Asian mountain site



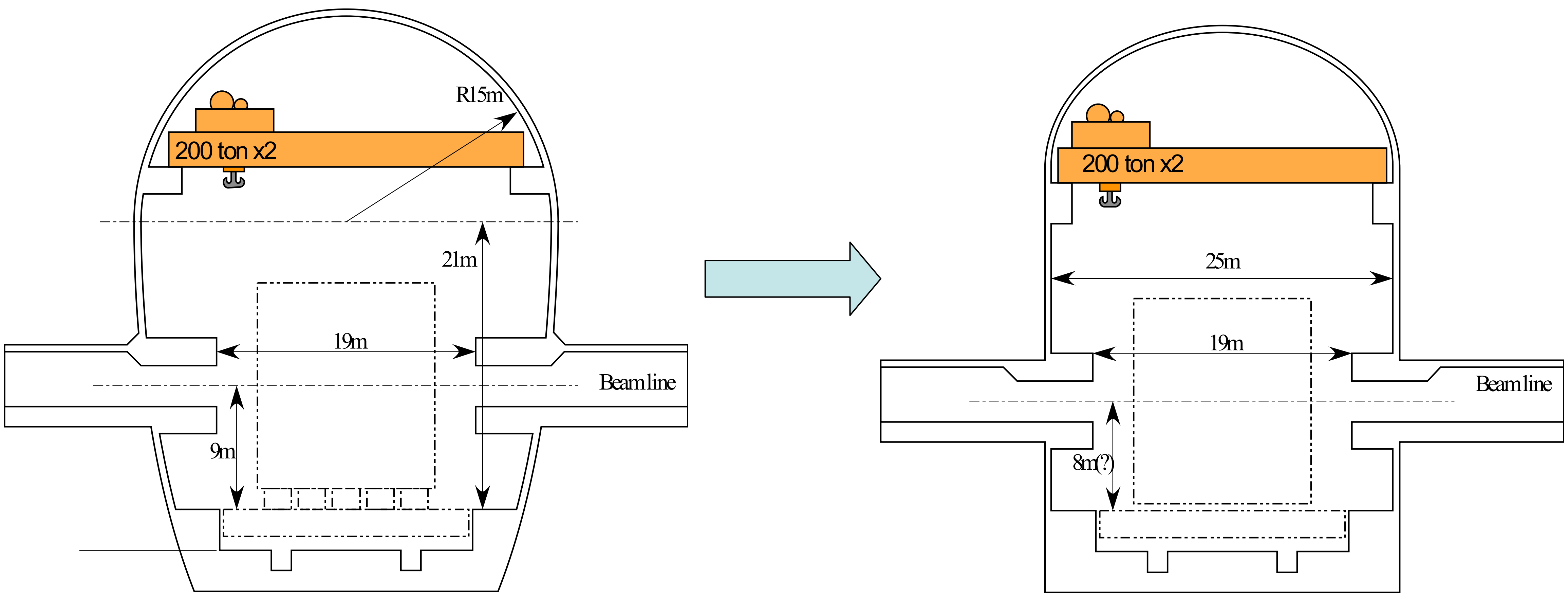
Y. Sugimoto, IWLC10, CERN/CICG, 8 Oct.2010

Without vertical shaft



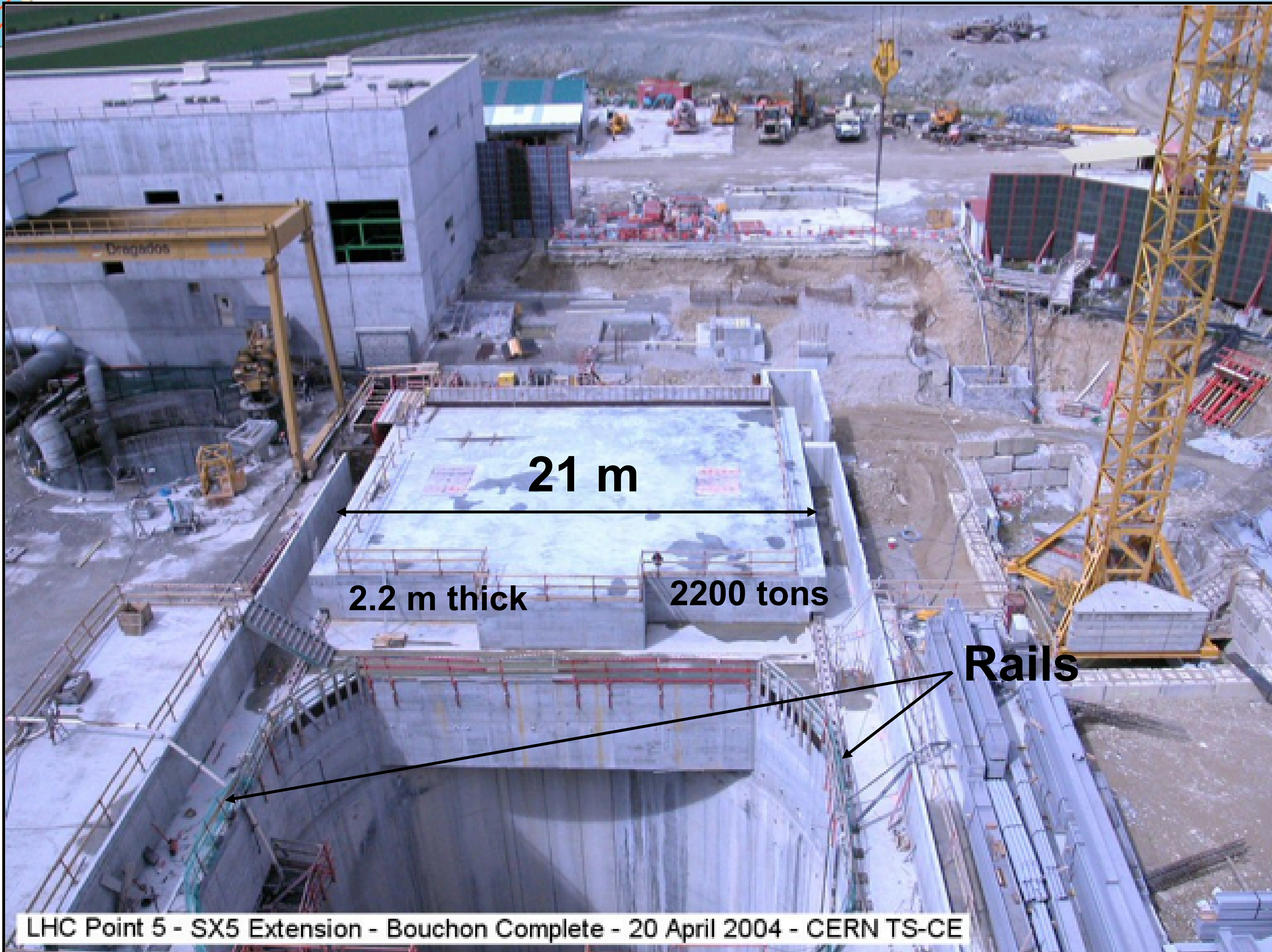
Shape of cavern

- Study of 2 sample sites
  - Both sites have very good geology of granite
  - Depth of the cavern is less than 300m
  - ➔ Shape of the caver can be bullet shape rather than egg shape



Y. Sugimoto, ALCPG11, 20 March, 2011

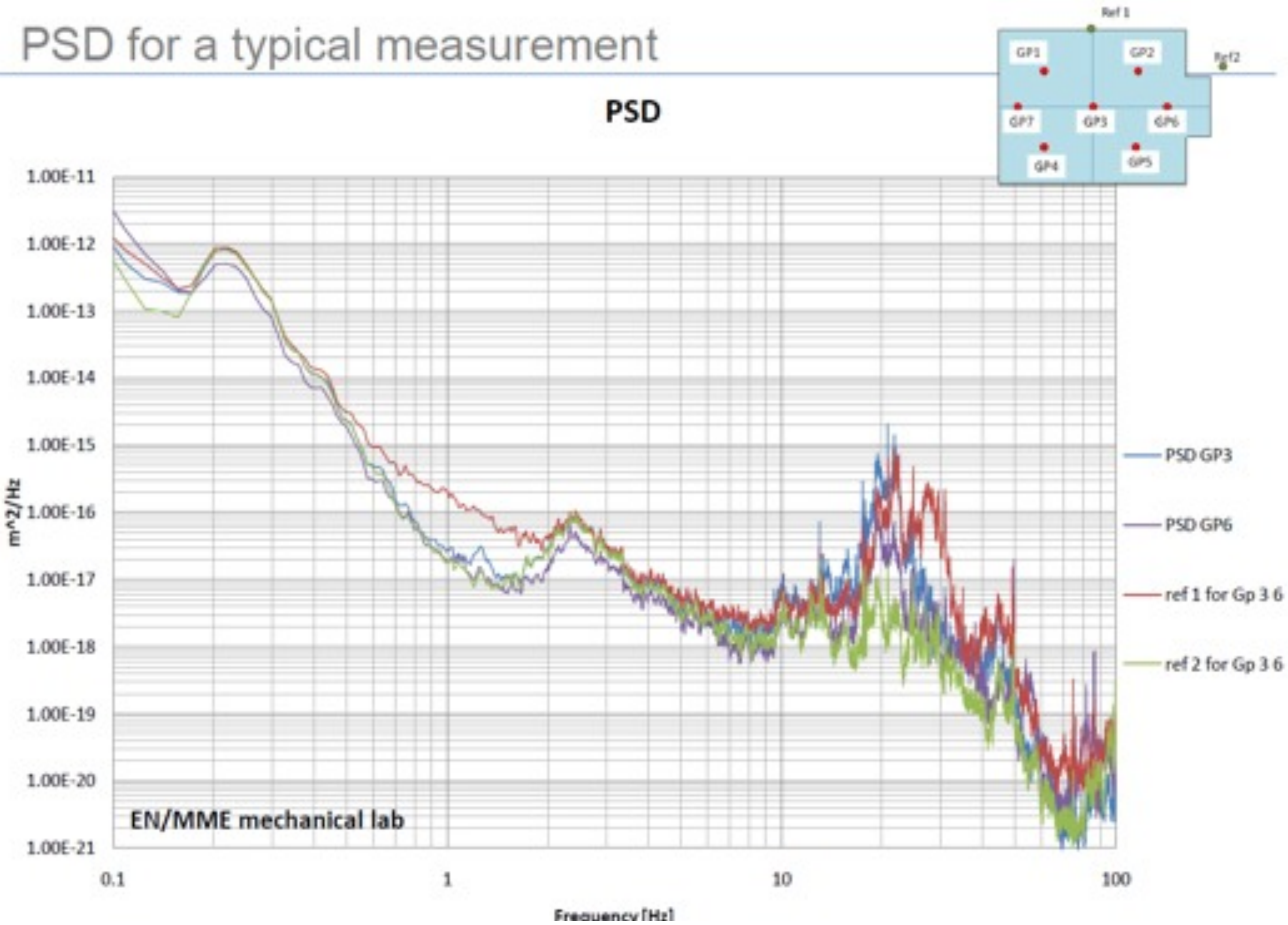
The CMS plug is good example of a platform



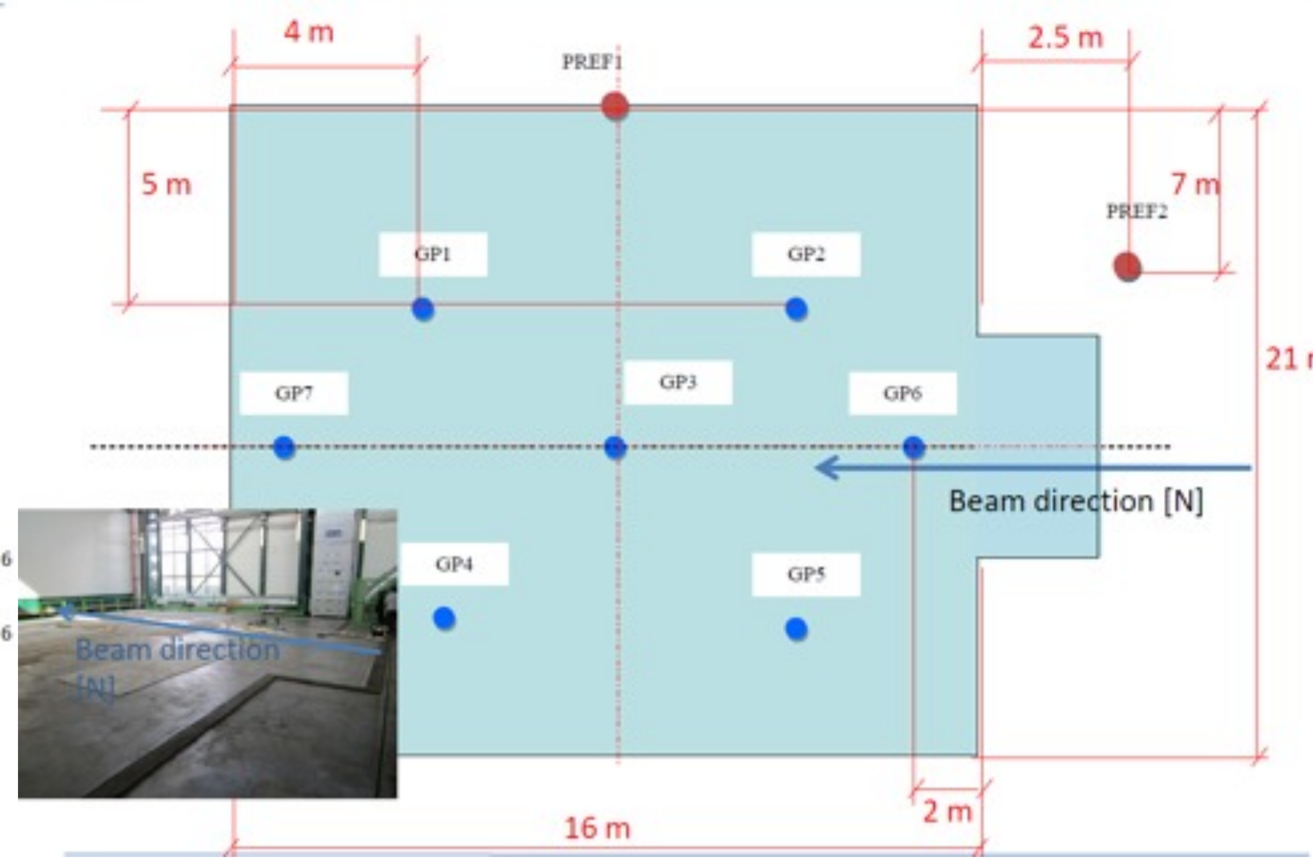
Experimental Vibration measurements – CMS Plug

by Marco Oriunno at ALCPG11

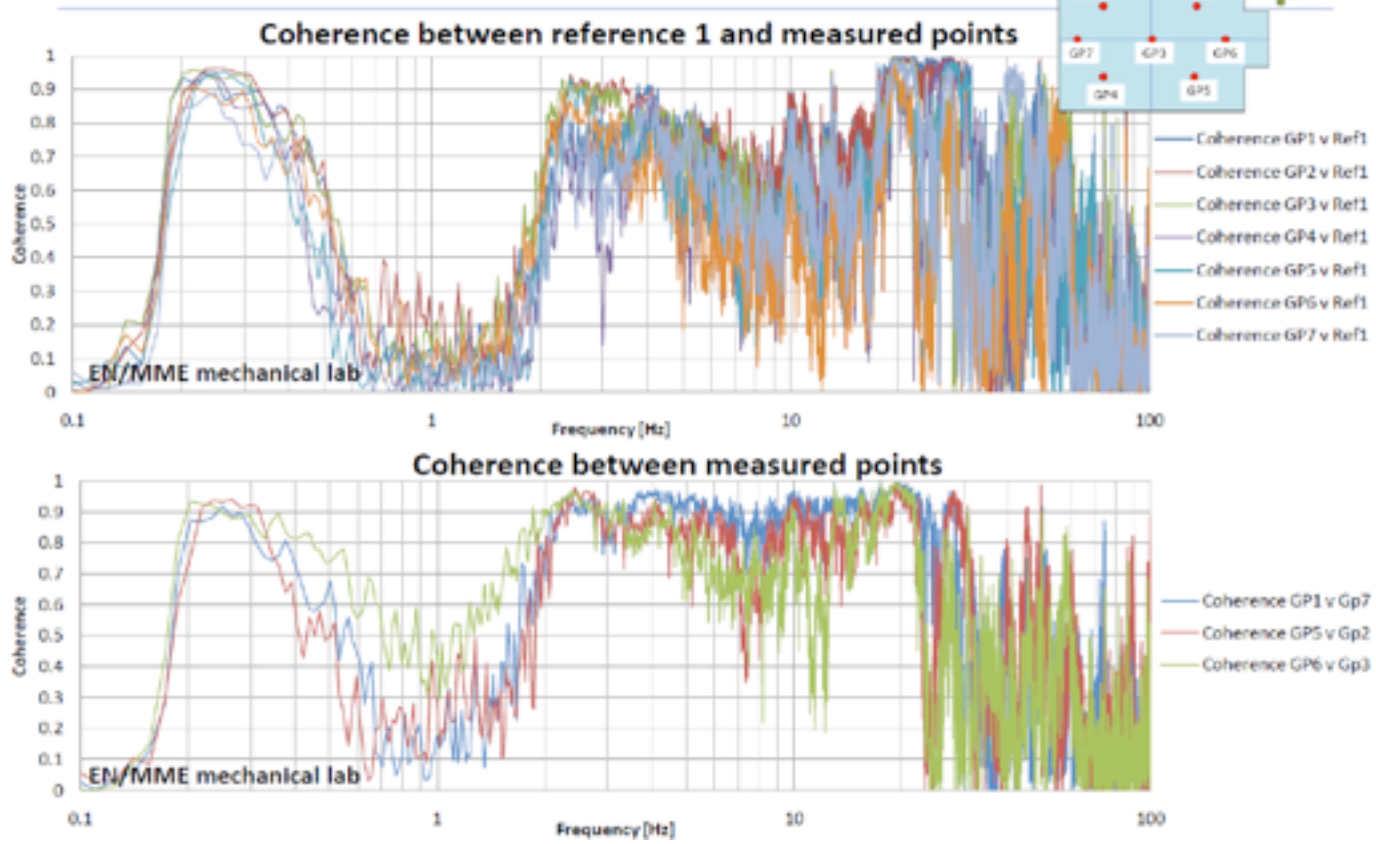
PSD for a typical measurement

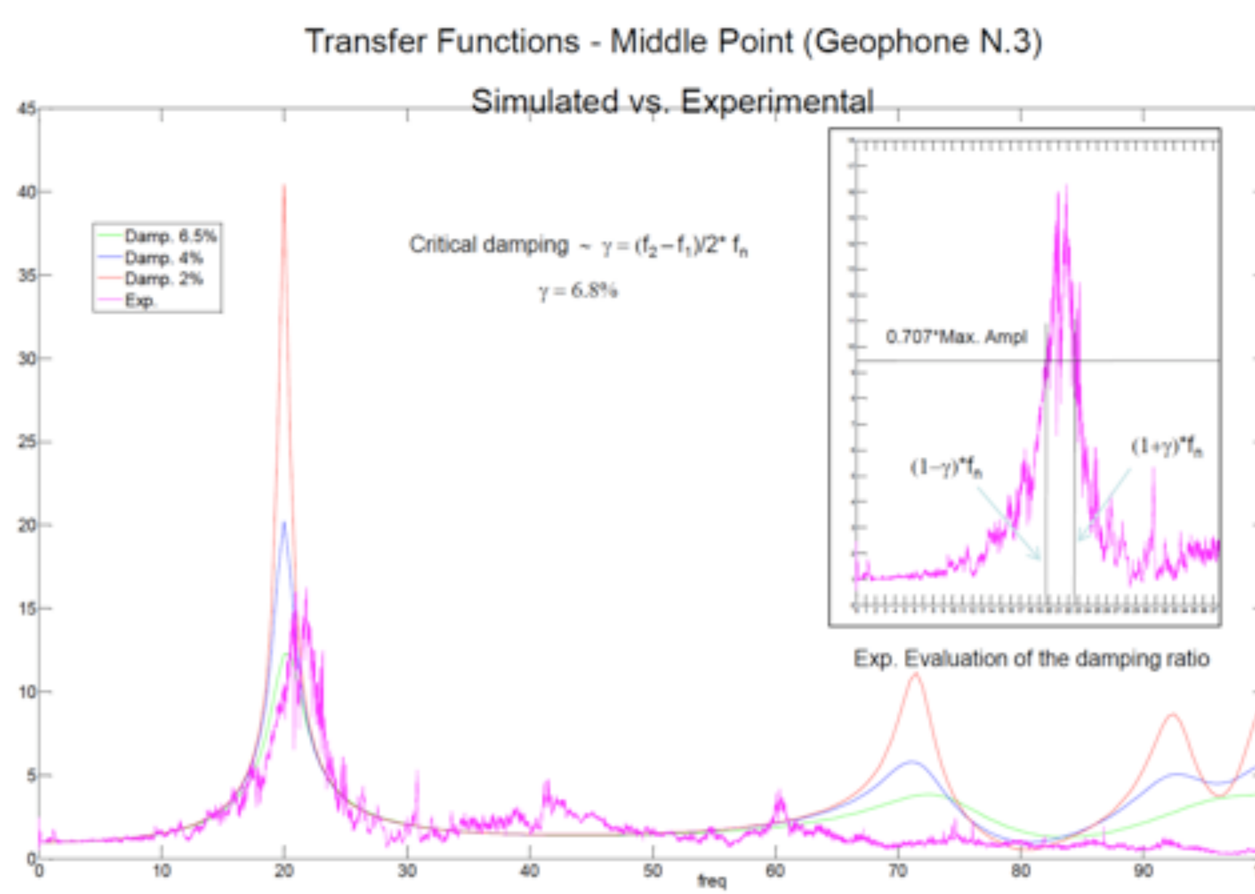


Sensor position



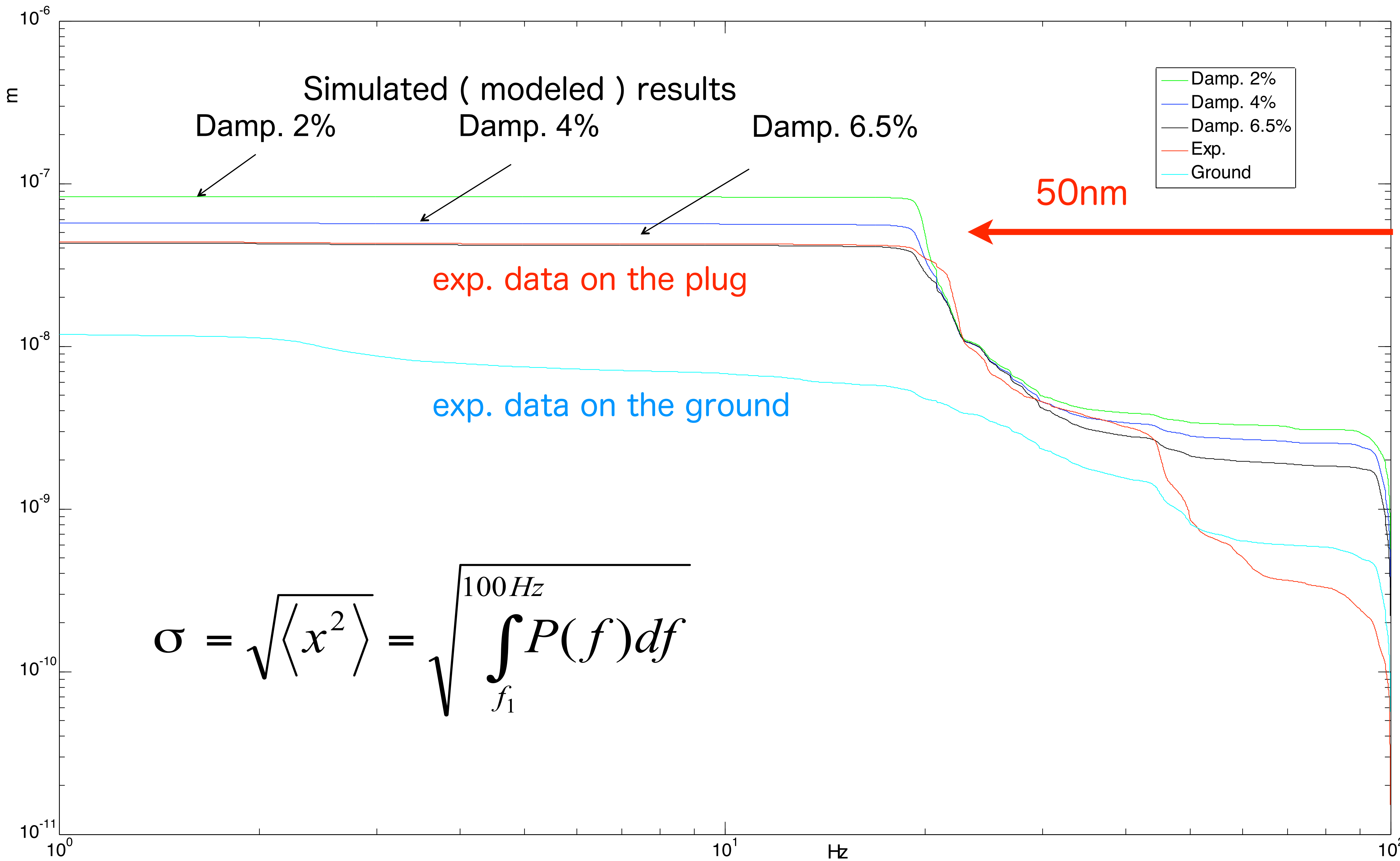
Coherence Vertical direction





Integrated Displacement σ (r.m.s.)

on the CMS plug



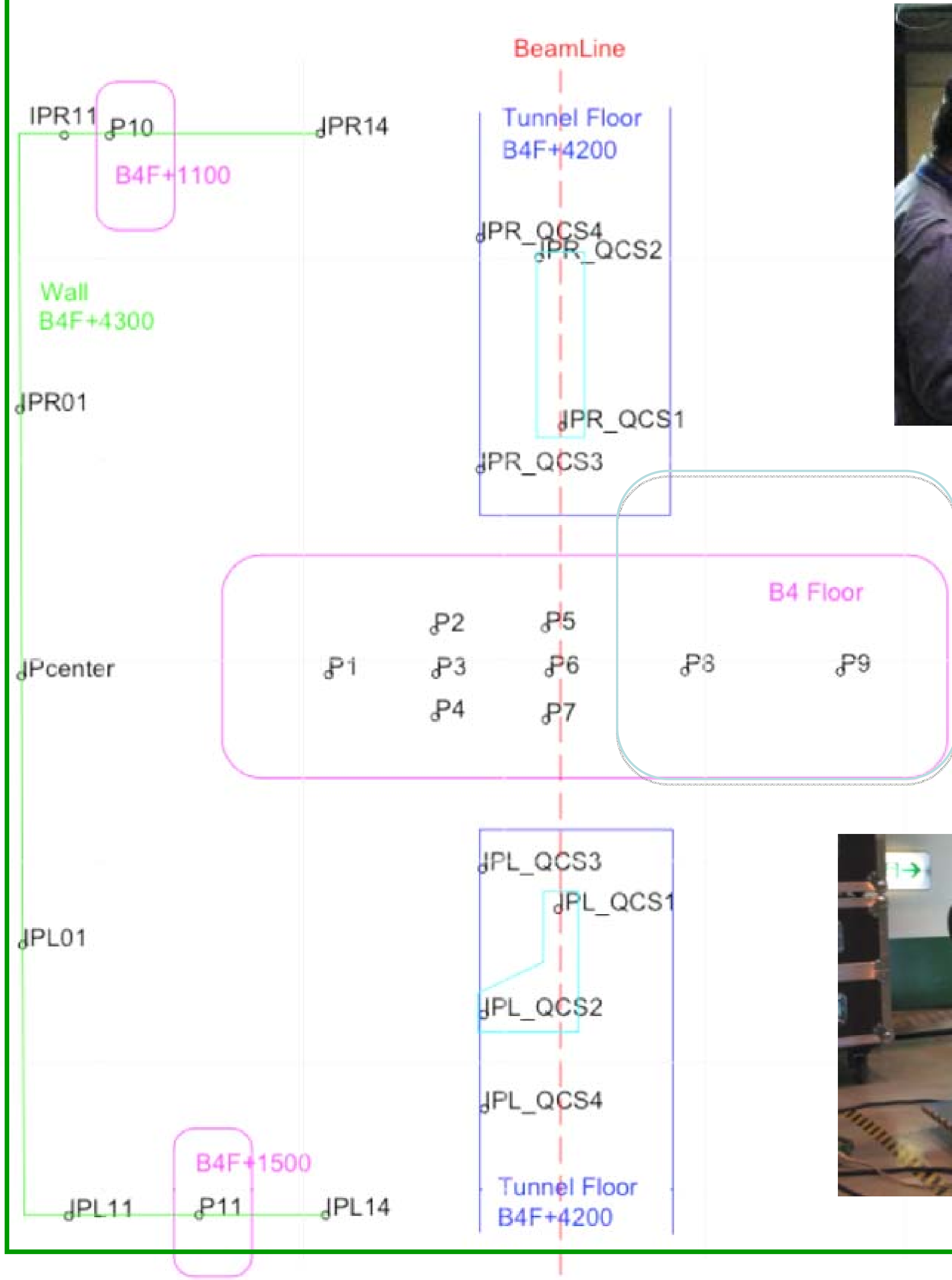
$$\sigma = \sqrt{\langle x^2 \rangle} = \sqrt{\int_{f_1}^{100\,Hz} P(f)\,df}$$

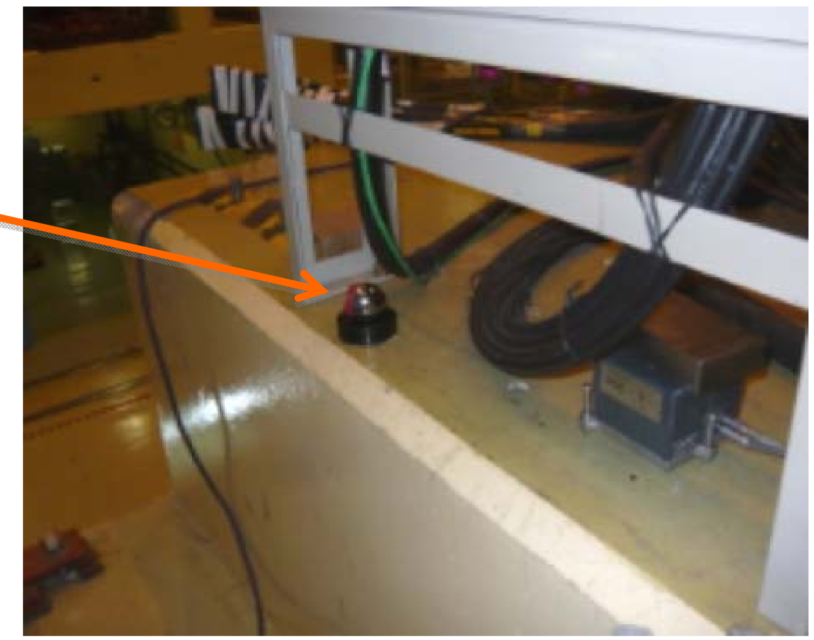
by Marco Oriunno at ALCPG11

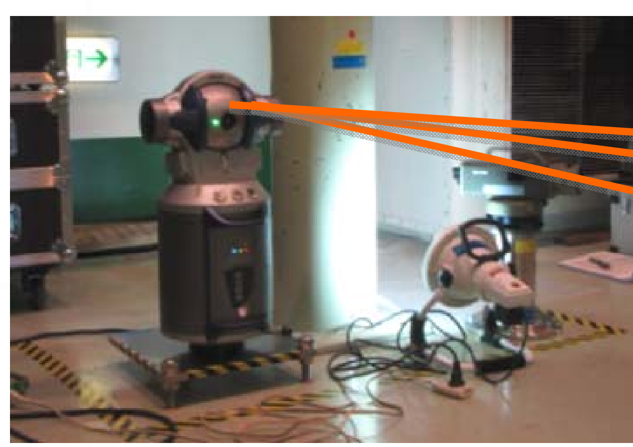
Made by Masuzawa-san@KEKB Revire

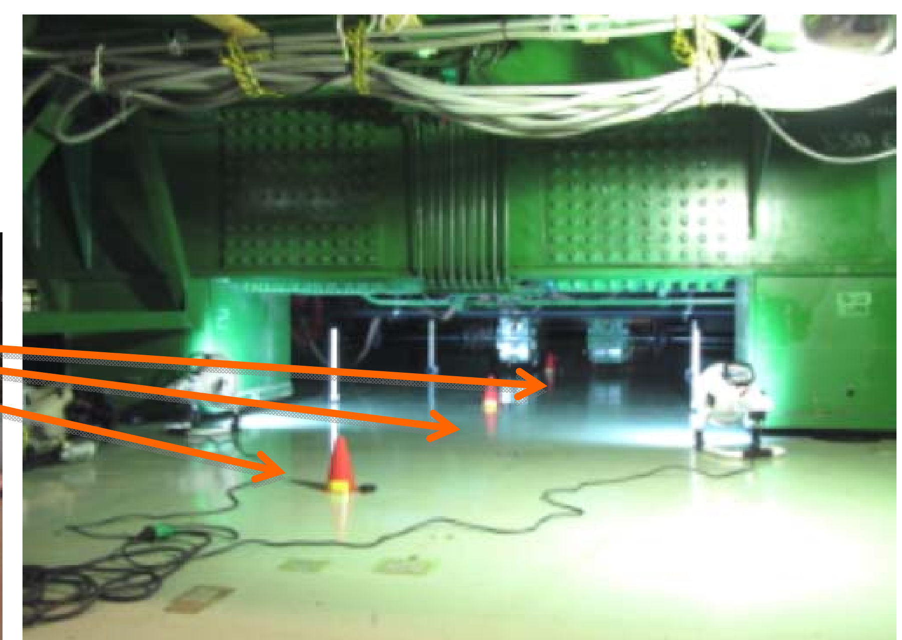
Beam line & floor motion during Belle roll-out analyzed.

Beam line floor & Cryostat (retracted) motion

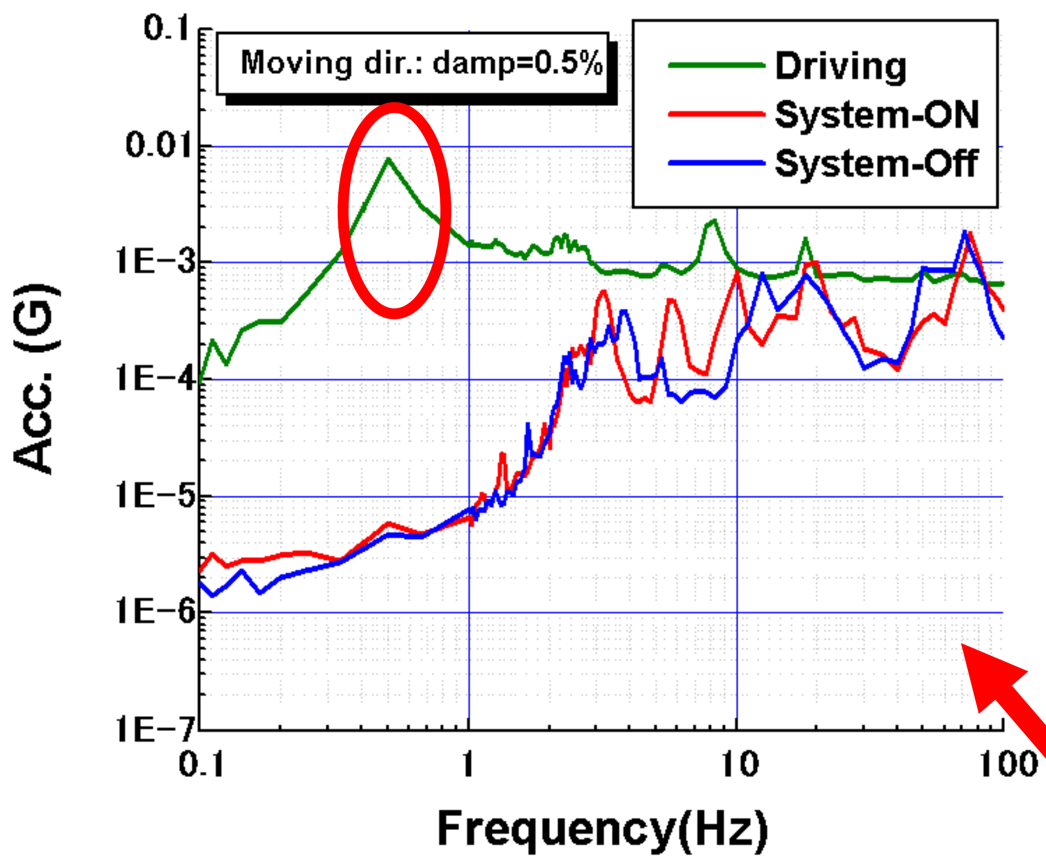


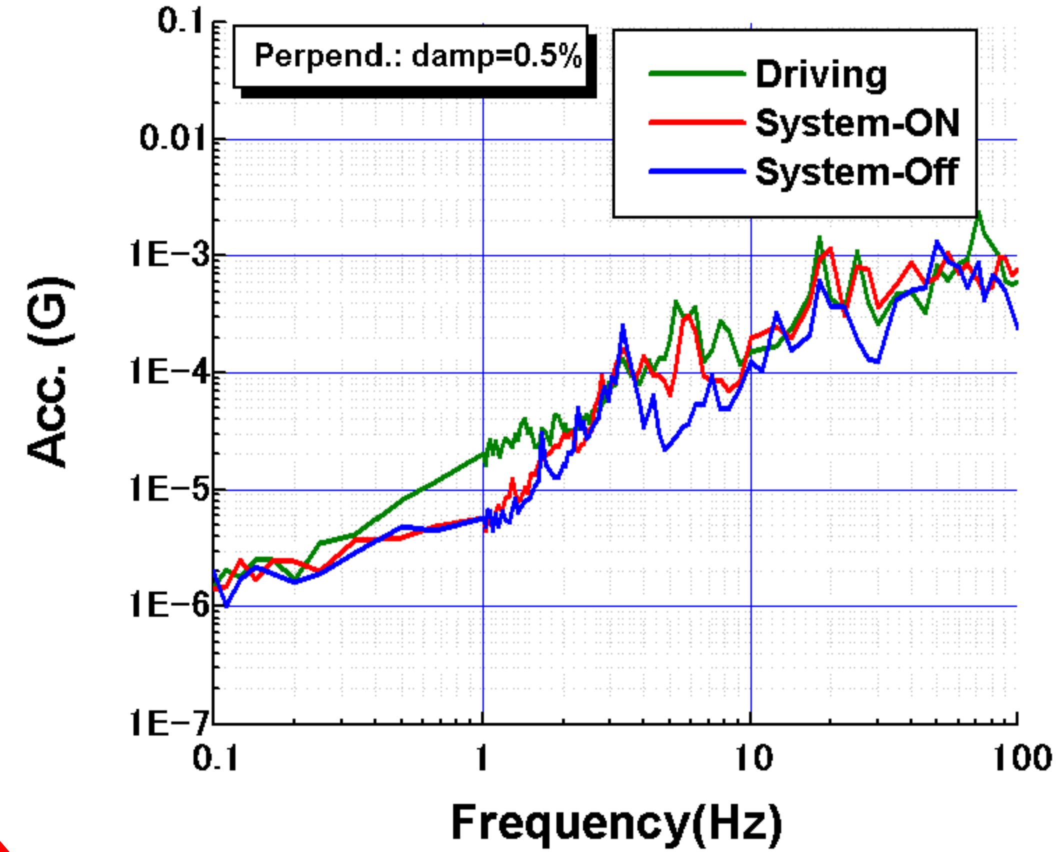


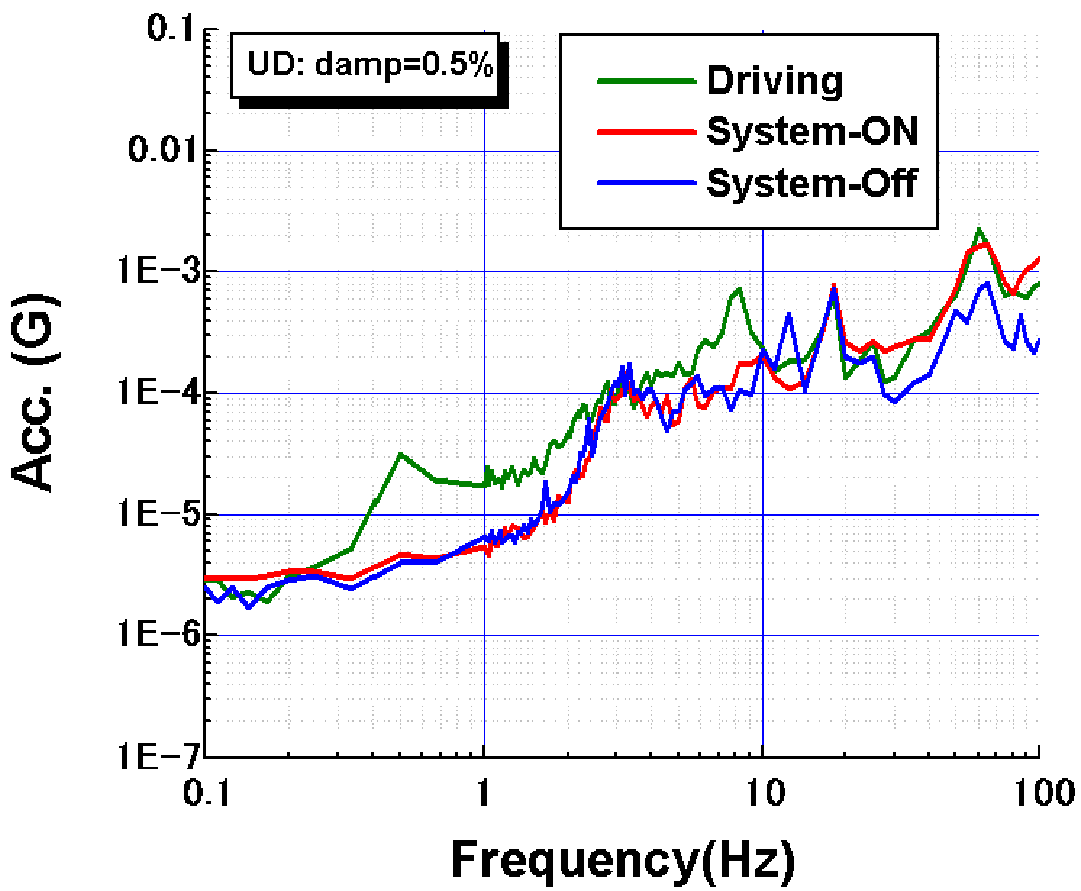




Response acceleration @platform (Belle detector 1,300t, 90cm/min)







Max. response acceleration ➔ ~0.01G

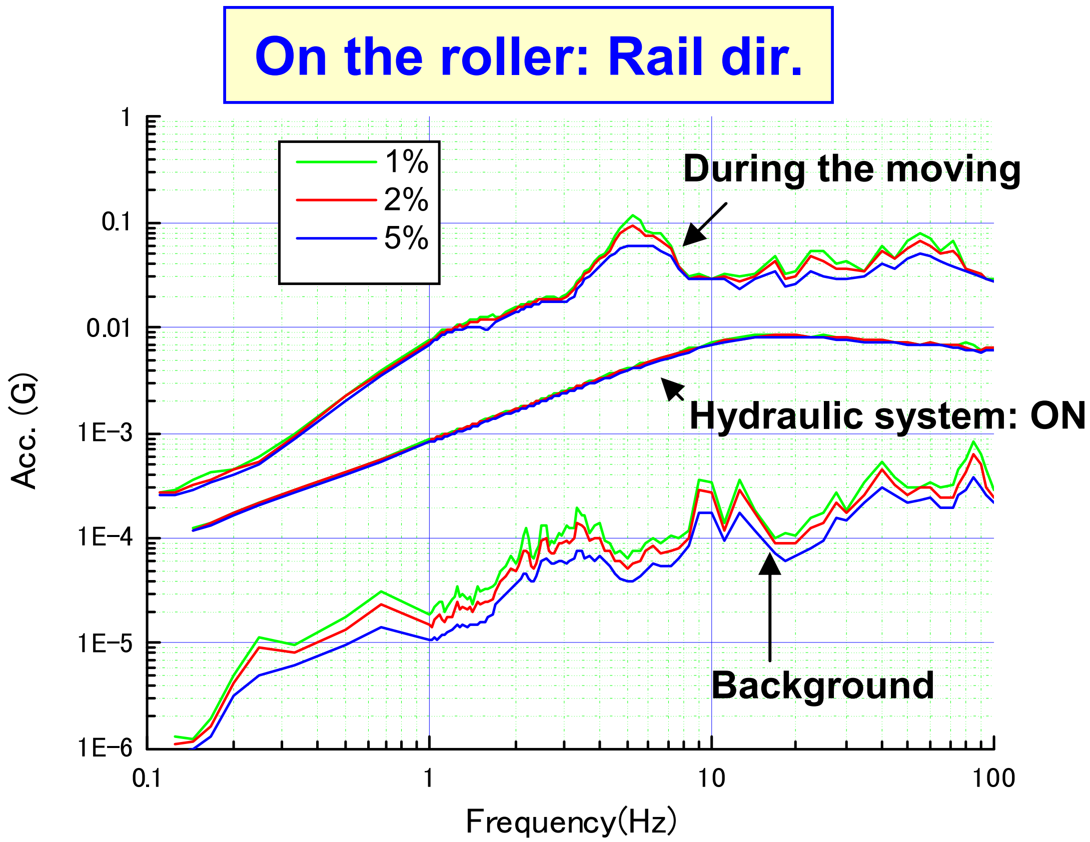
Seismic criteria for the Belle detector

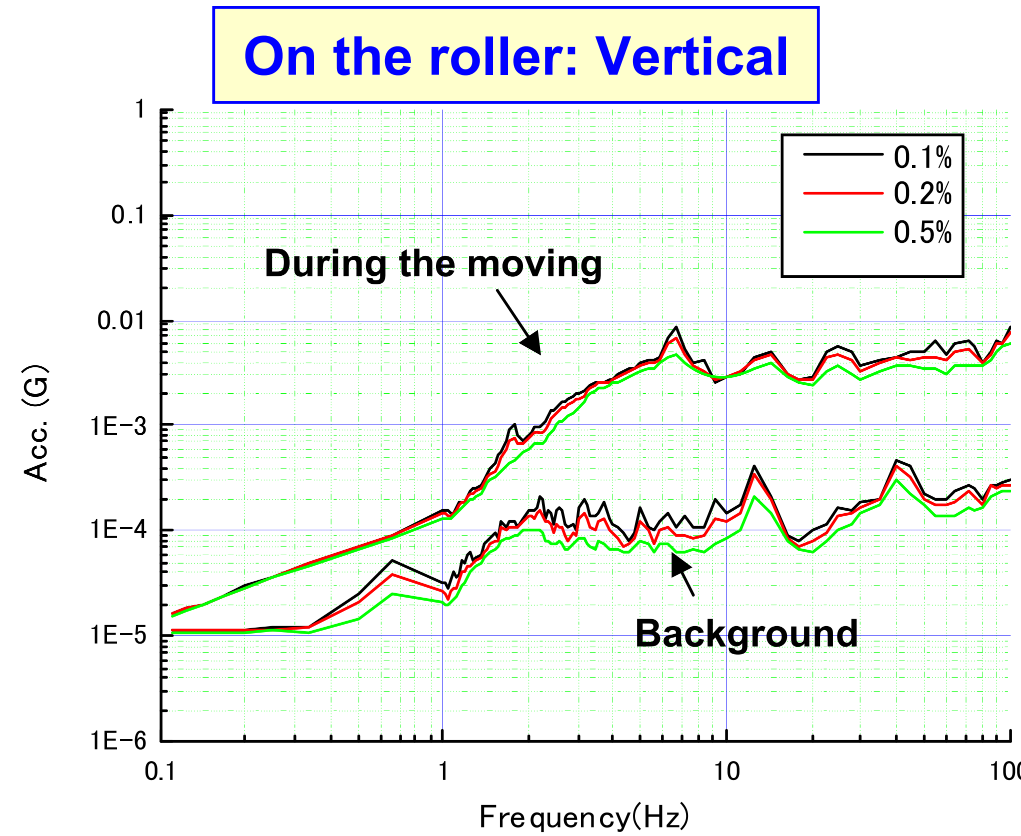
➔ 0.3G

→ 0.01G of respond acc .is very small.

➔ This seismic level is safe enough.

Response acceleration@ND280 (450t, 50cm/min, 1m/stroke)





Response acceleration → ~0.1G
→ ~0.01G(Belle)

Seismic criteria for the ND280

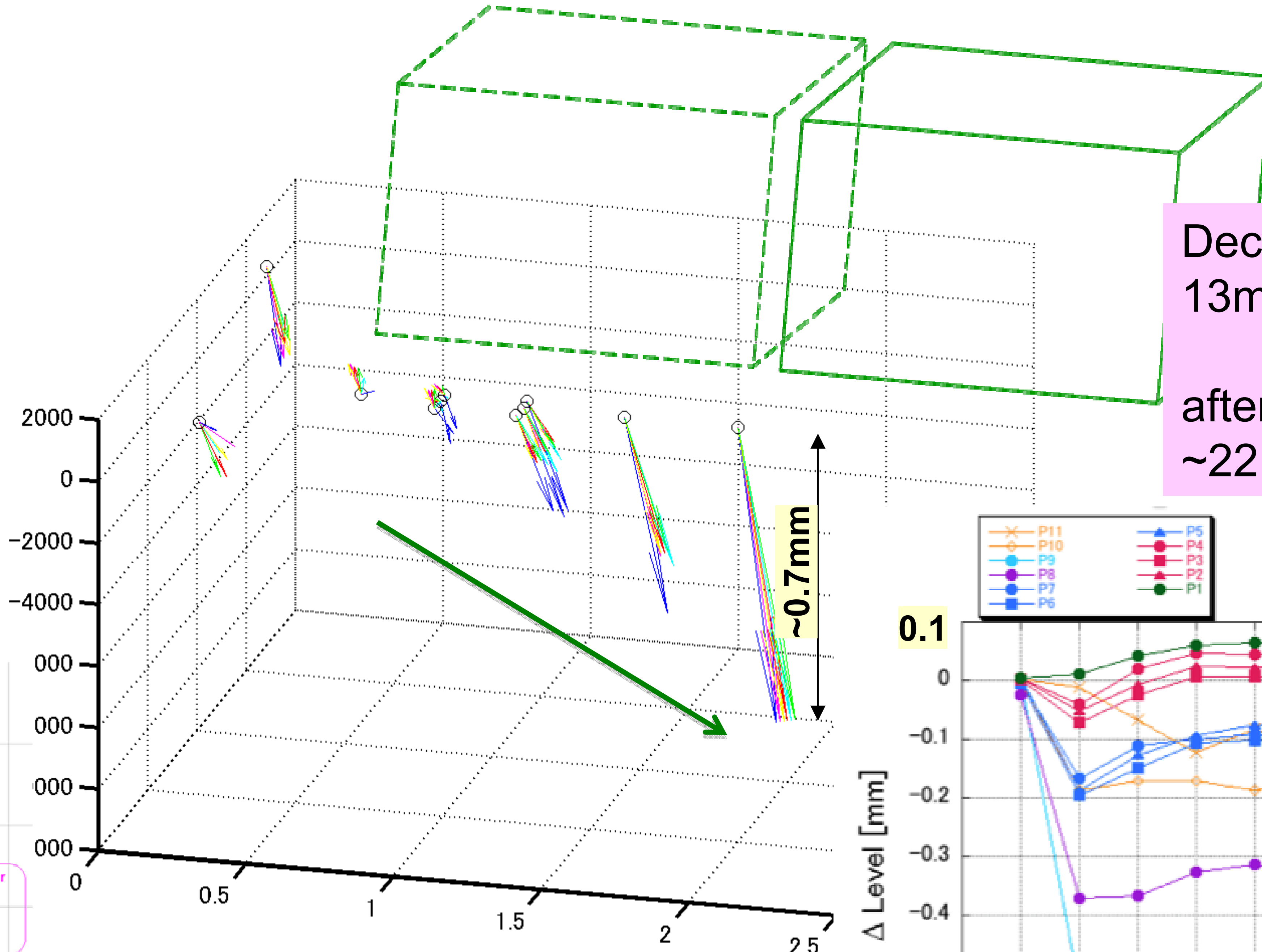
→ **0.5G**

→ **0.1G of Acc is less than the criteria.**

→ **But 10 time bigger than the Belle moving system.**

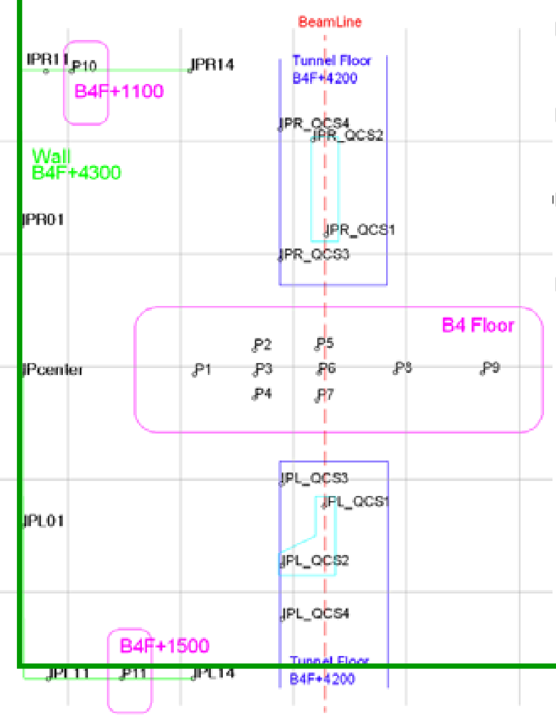
Made by Masuzawa-san@KEKB Review

Vertical motion of the B4 floor

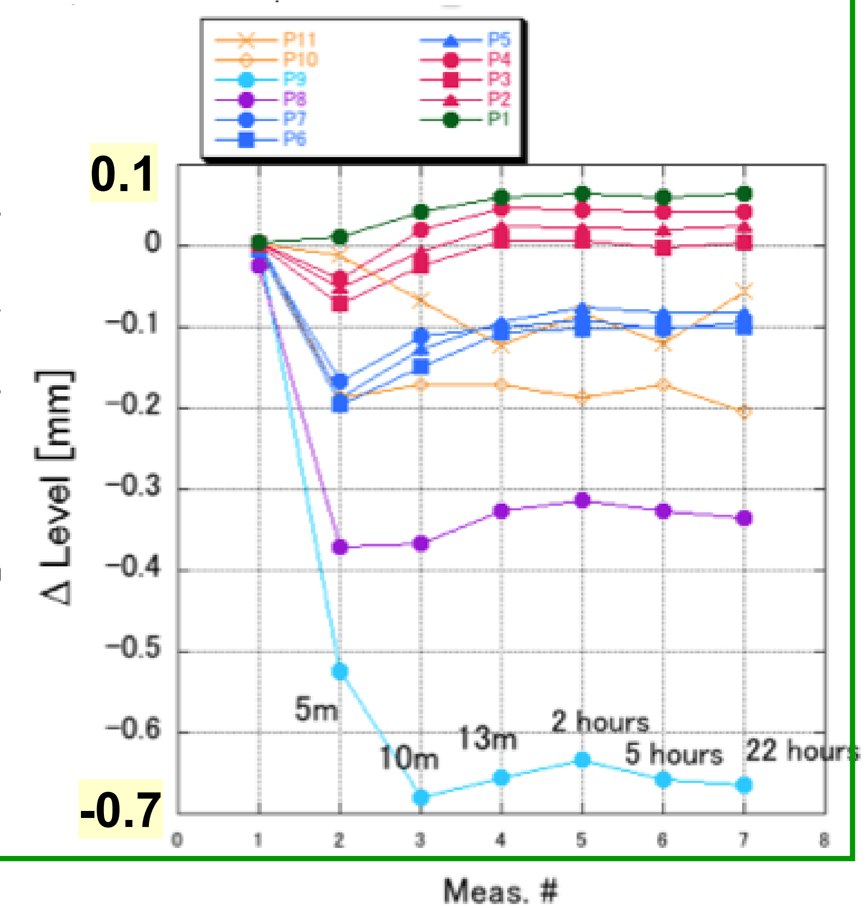


Dec.10 9:00
13m

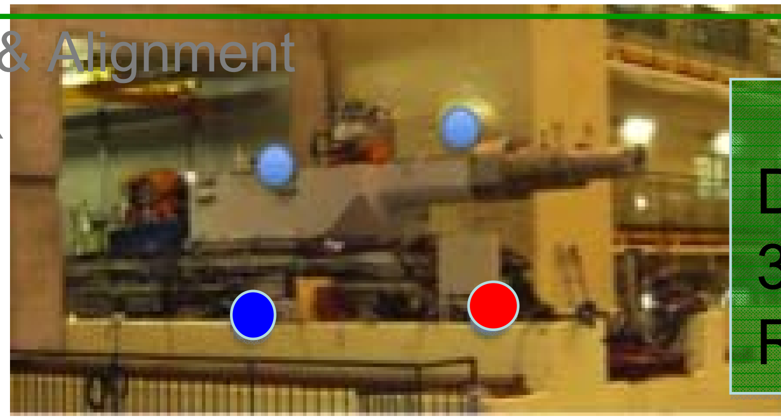
after
~22 hours



Experimental building floor (B4 floor) tilts towards Belle

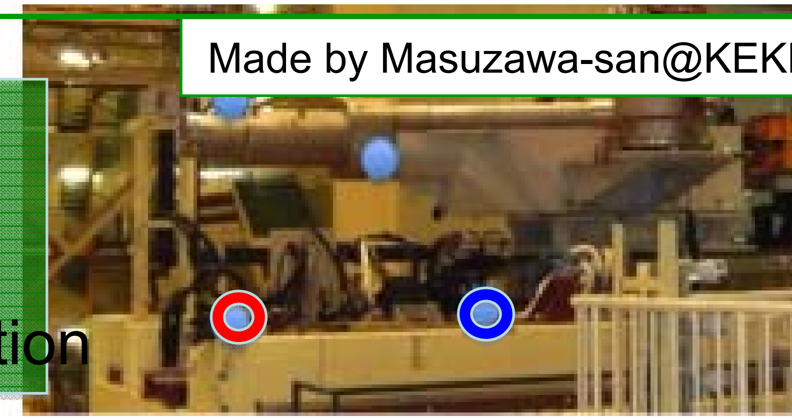


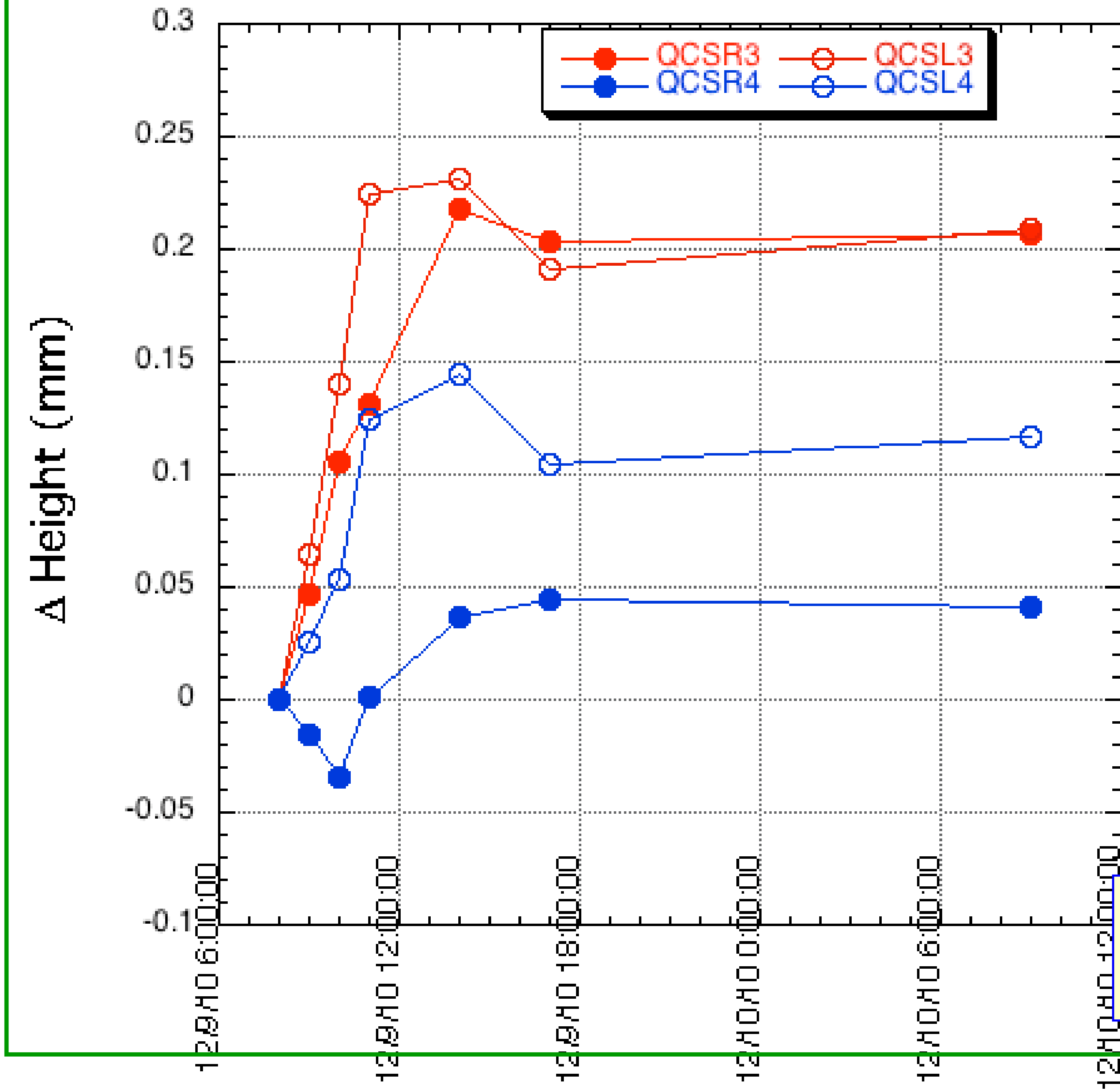
4. Survey & Alignment Status : IR



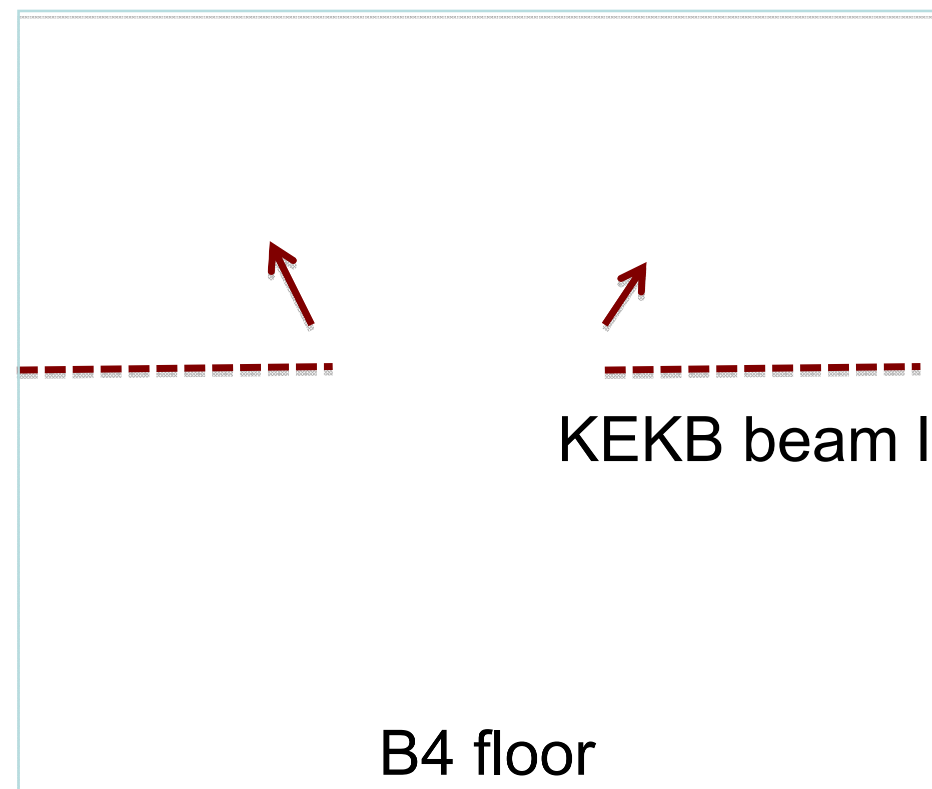
Made by Masuzawa-san@KEKB Review

Dec. 9th 14:00
3 hours from
Roll-out completion





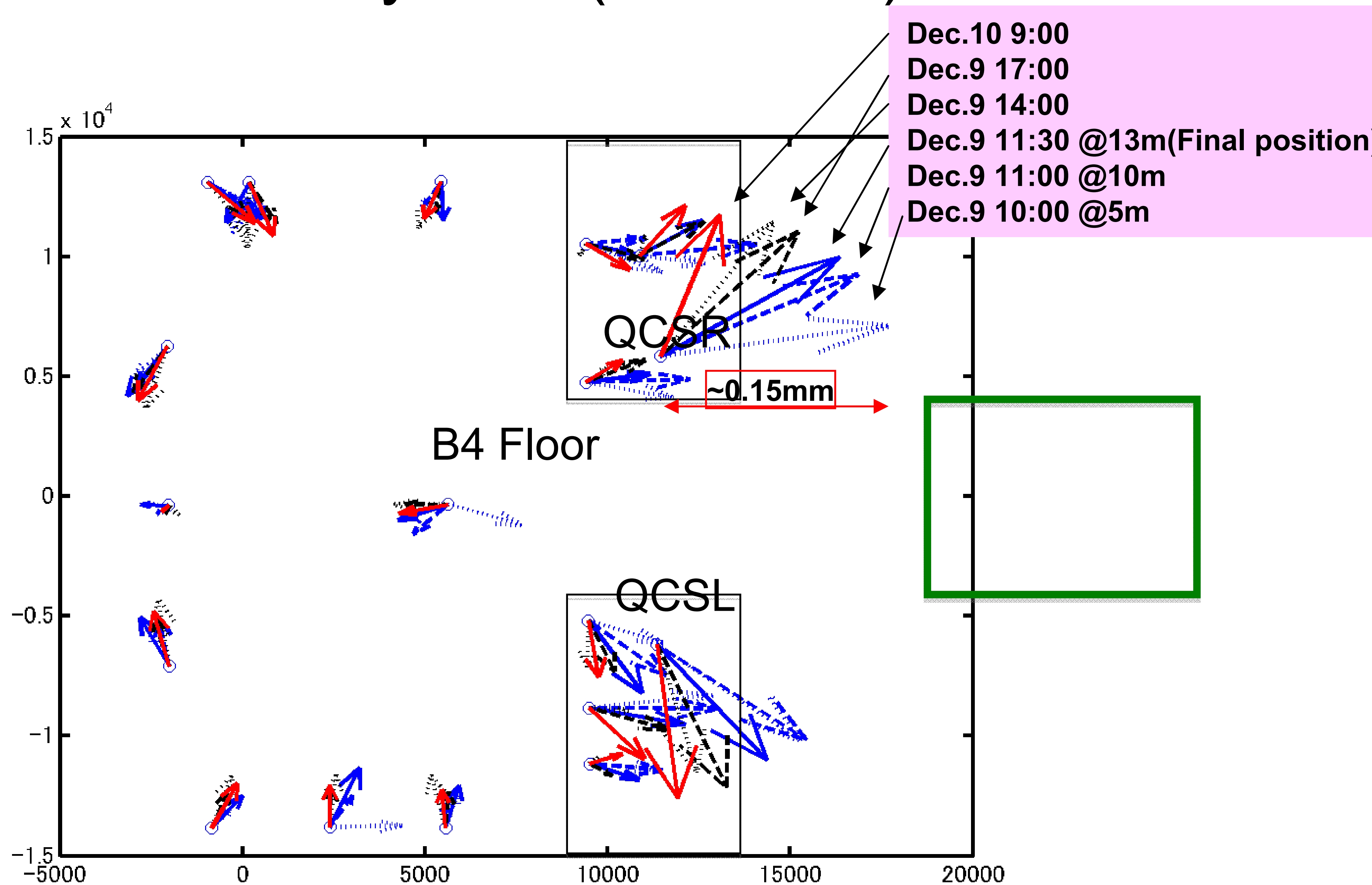
Tsukuba experimental hall



KEKB beam line opens up like
a drawbridge when Belle moves away.

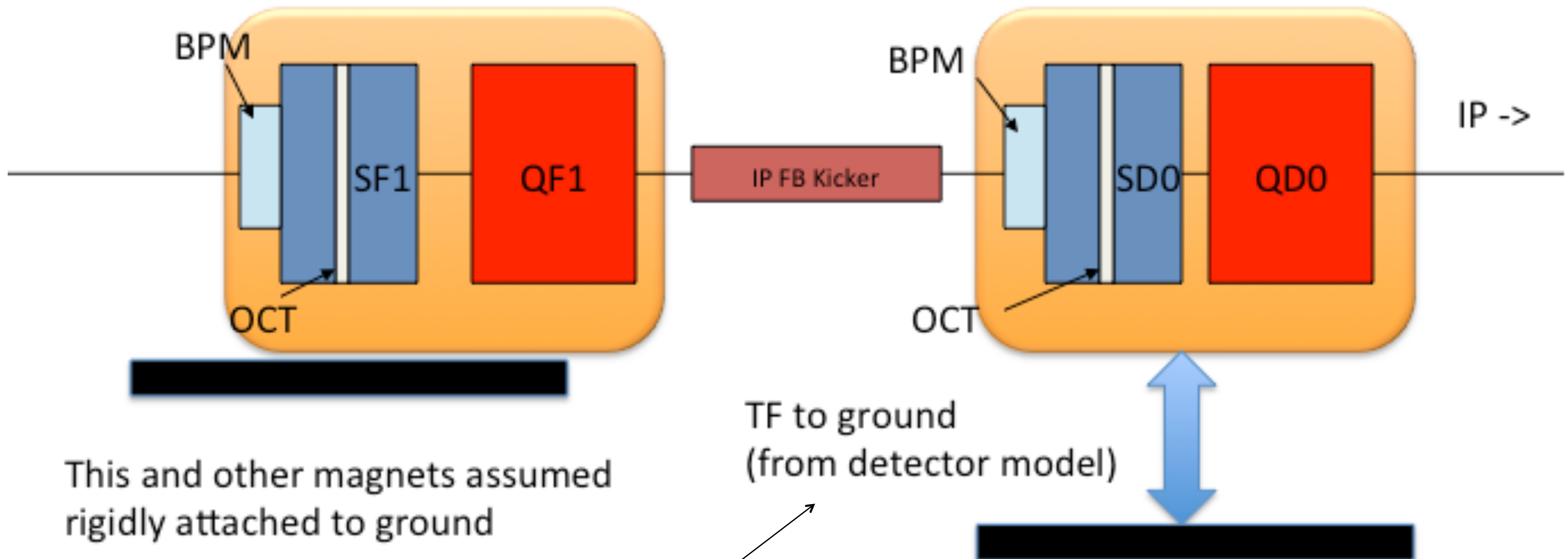
Made by Masuzawa-san@KEKB Review

Horizontal motion of the B4 floor & beam line floor & Cryostat (retracted)

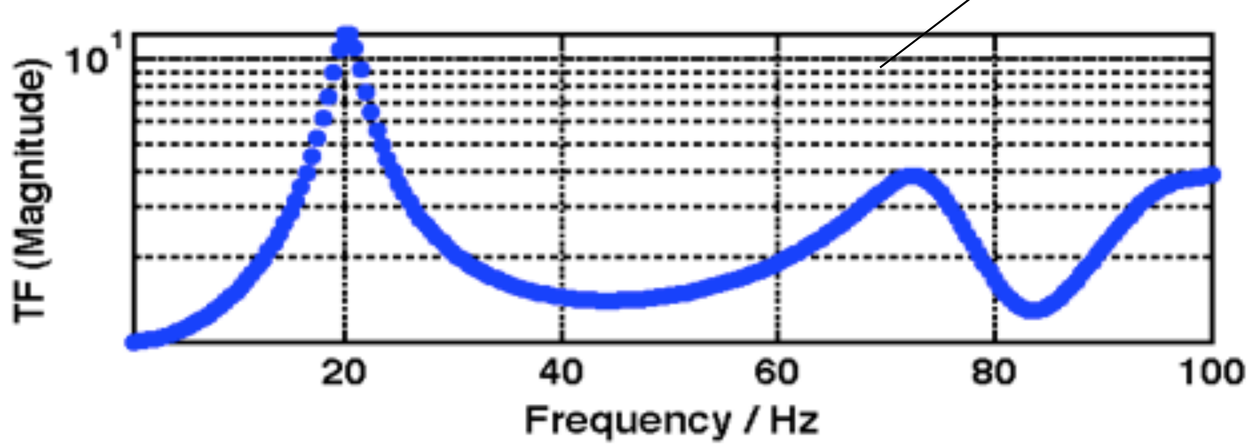


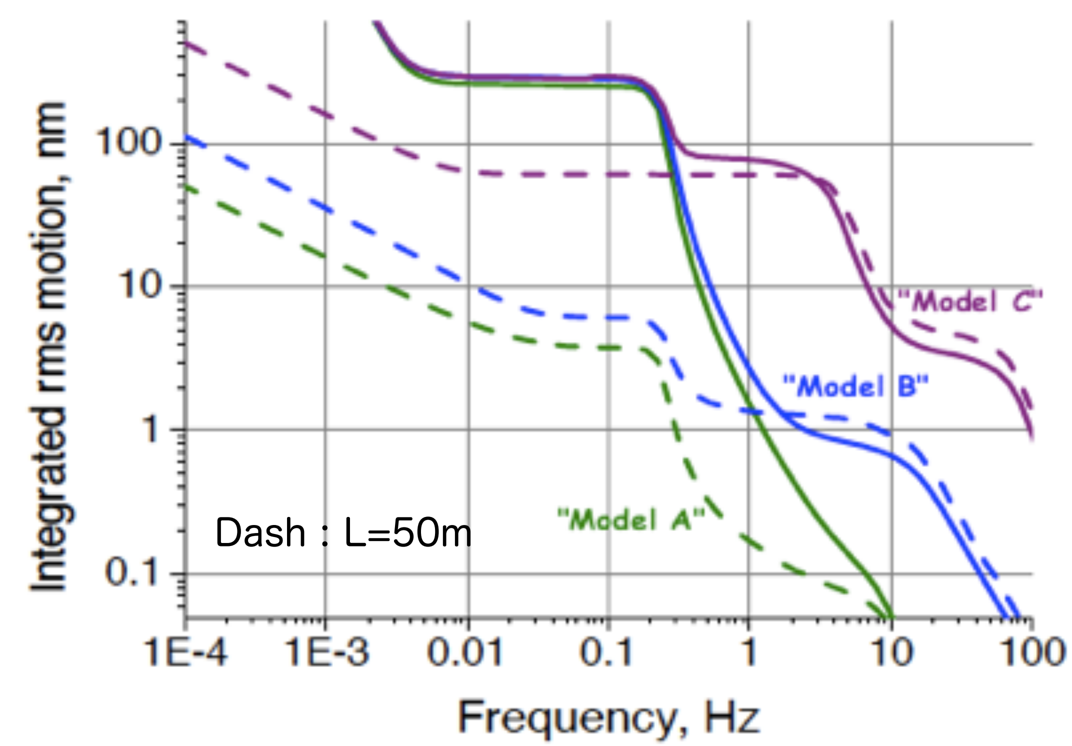
Belle pulls the beam line with it.

IP Region Final Doublet



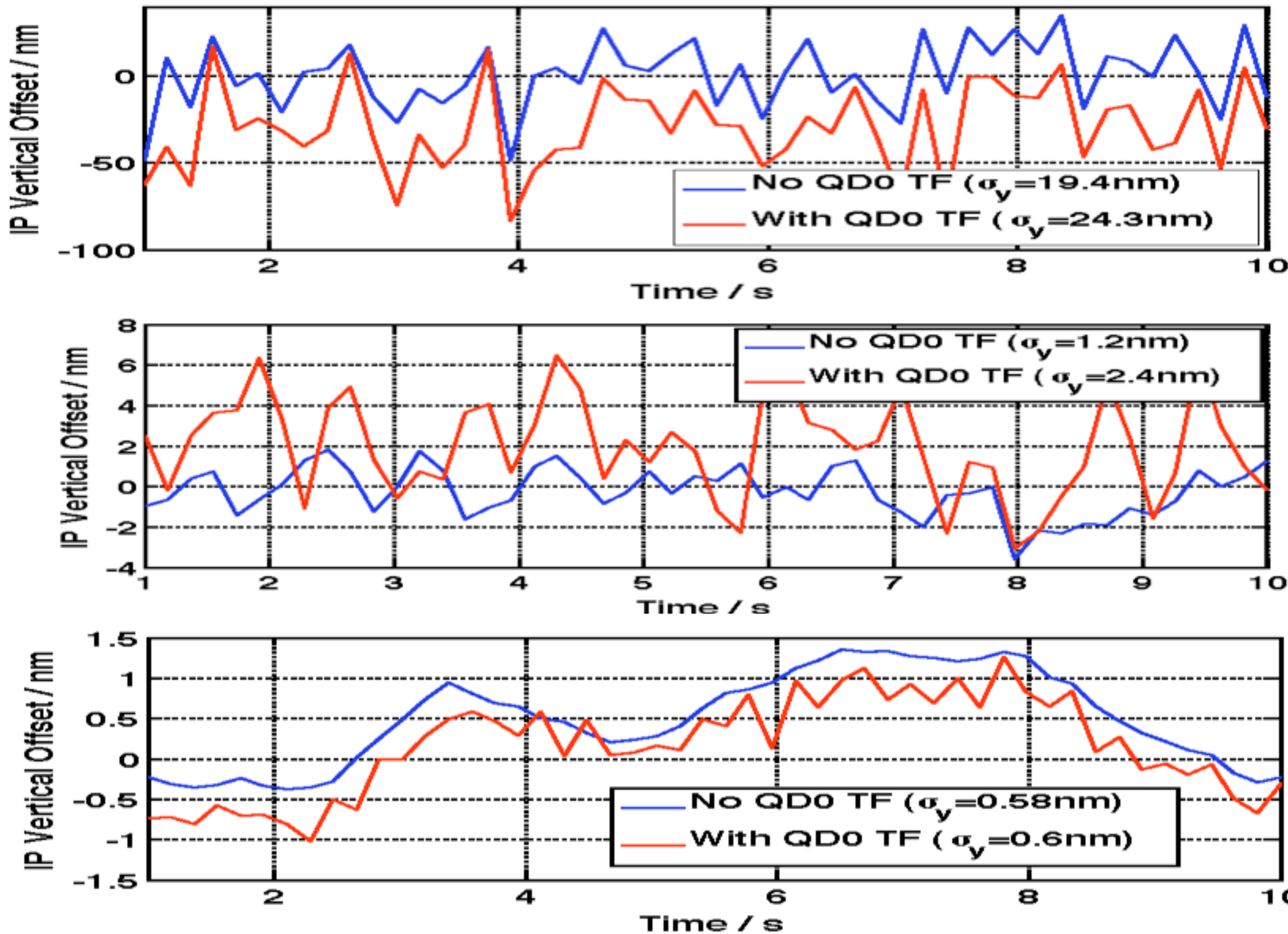
Rigid support model from SiD
(M.Oriunno)





Glen White/ SLAC , ALCPG11

GM Induced Jitter @ IP (Vertical Offset between e- and e+ beams at IP) with and without QD0 TF



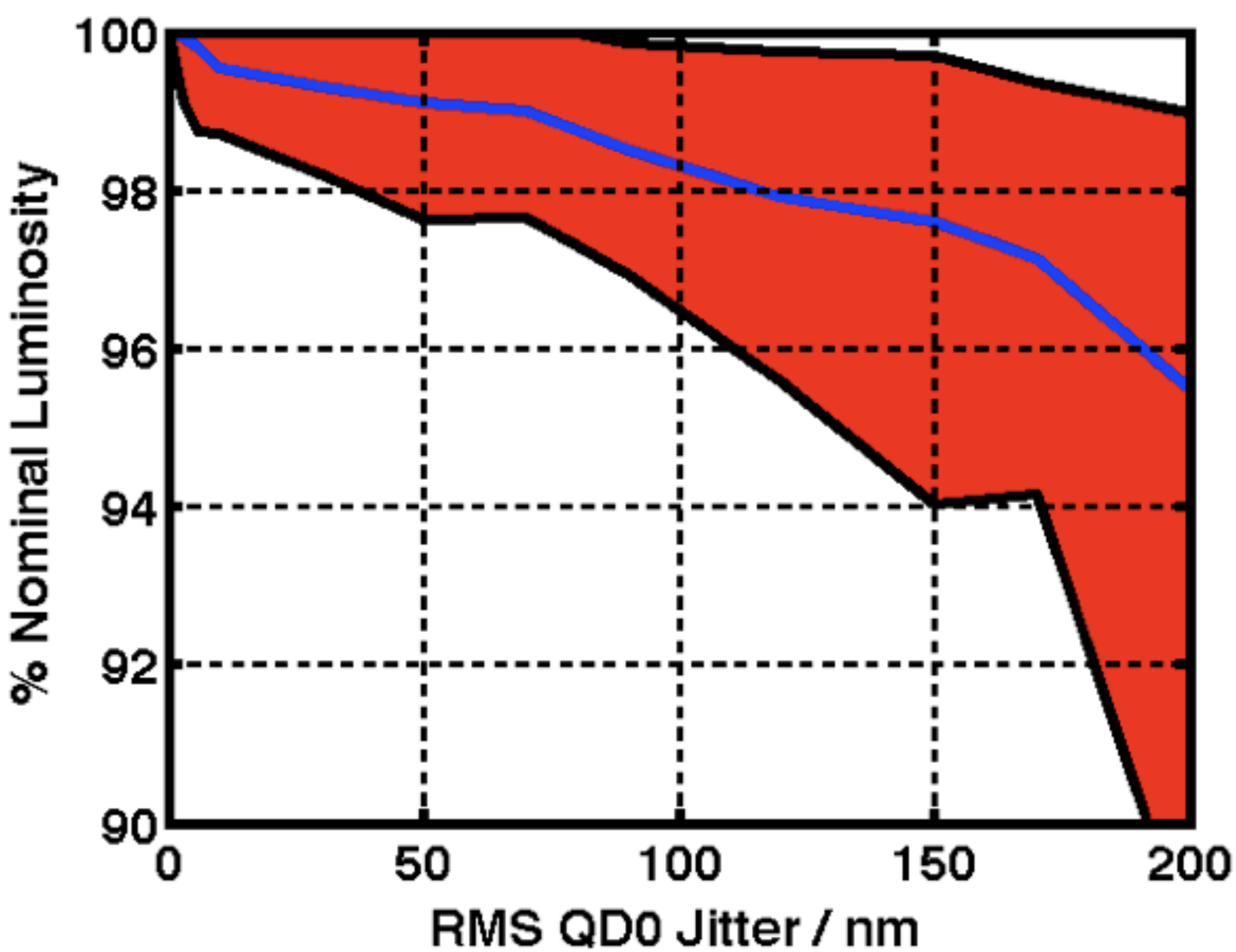
GM'C'

GM'B'

GM'A'

Glen White/ SLAC , ALCPG11

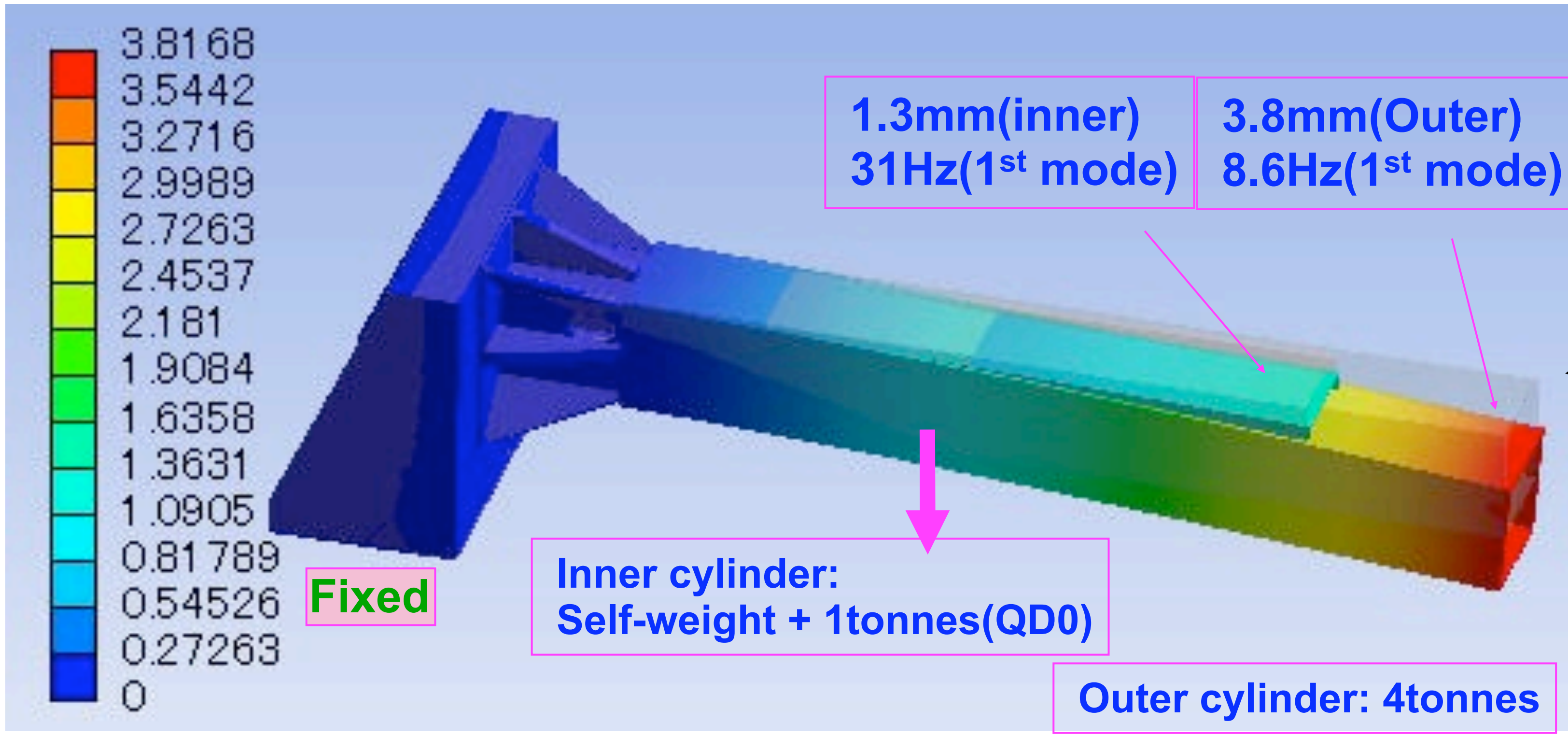
Luminosity Loss vs. QD0 Jitter

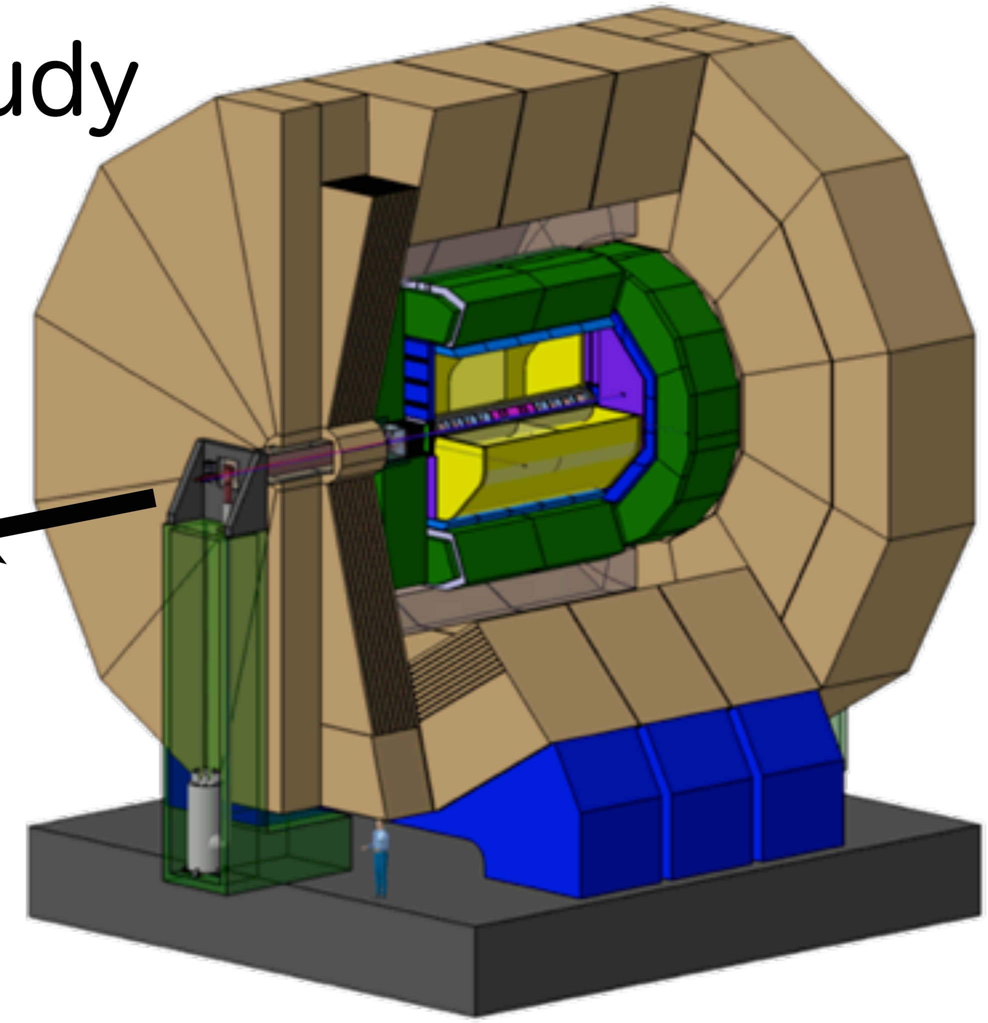


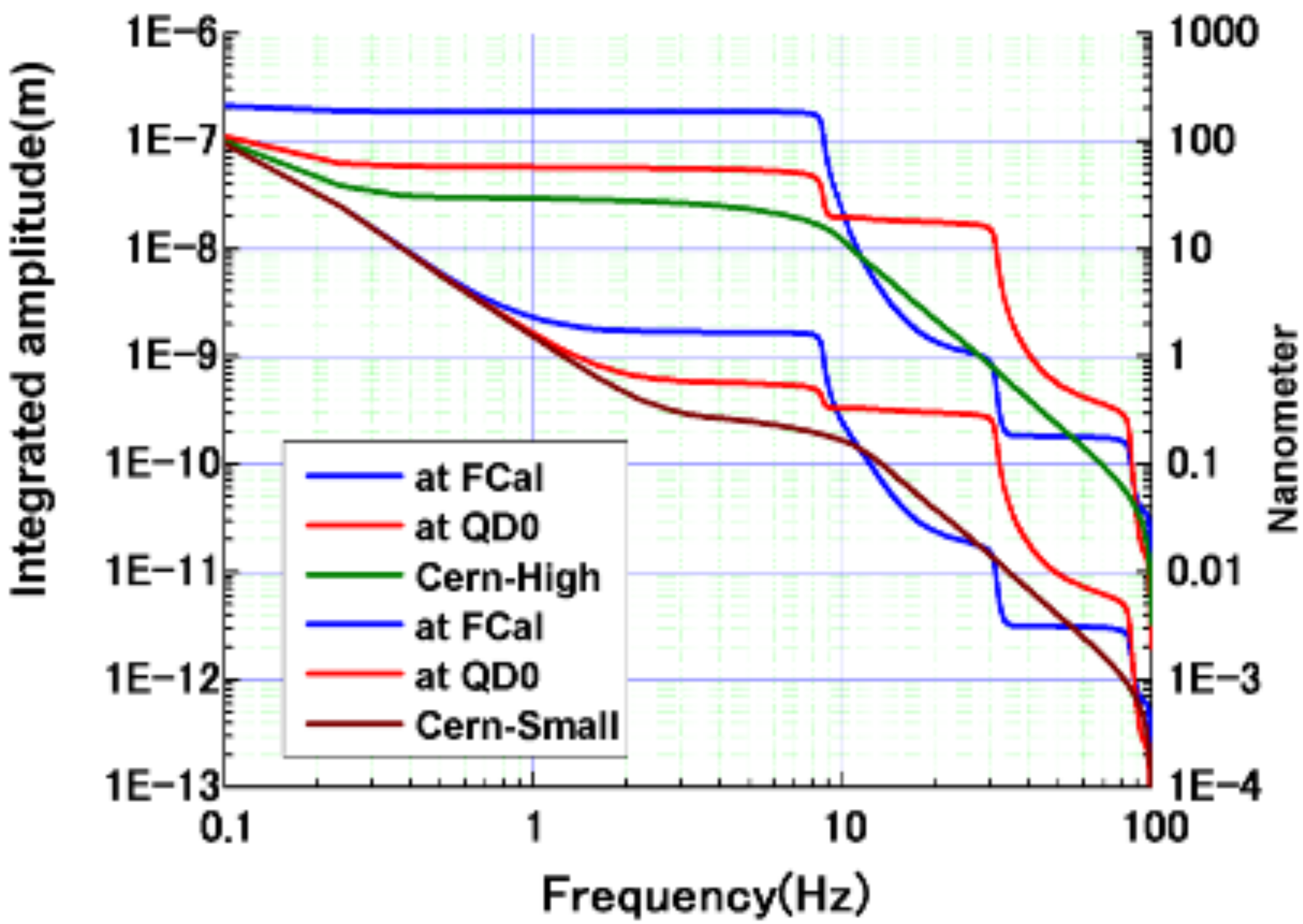
- Data shown gives % nominal luminosity for different levels of uncorrelated QD0 jitter.
  - 100 pulses simulated per jitter cases with FFB
  - Mean, 10% & 90% CL results shown for each jitter point from 100 pulse simulations
- **Tolerance to keep luminosity loss <1% is <50nm RMS QD0 jitter.**

Glen White/ SLAC , ALCPG11

ILD : QD0 Vibration Study







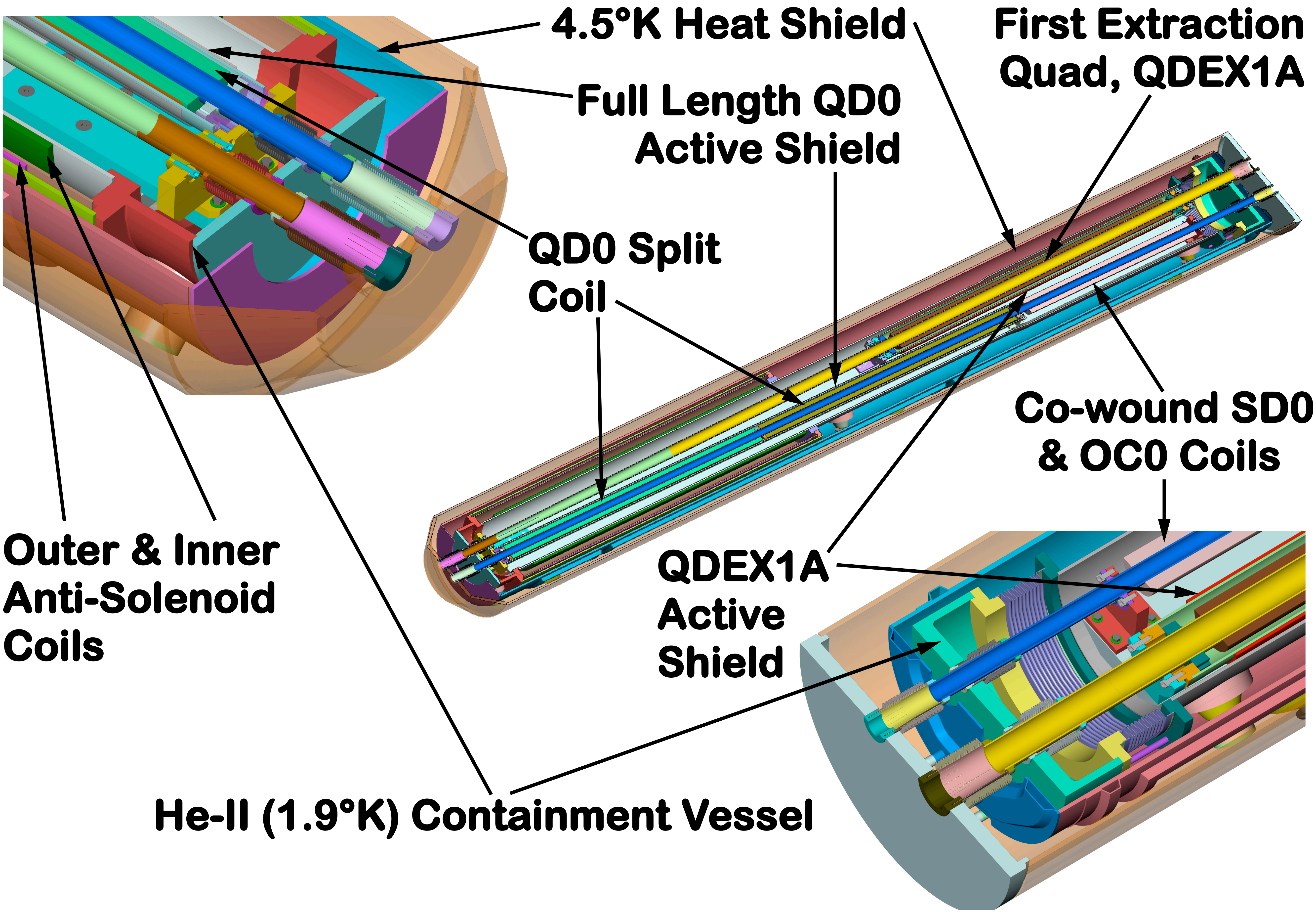
54nm @ f>5Hz at CERN-High (between Model C and B)

0.6nm @ f>5Hz at CERN-Small (~model B)

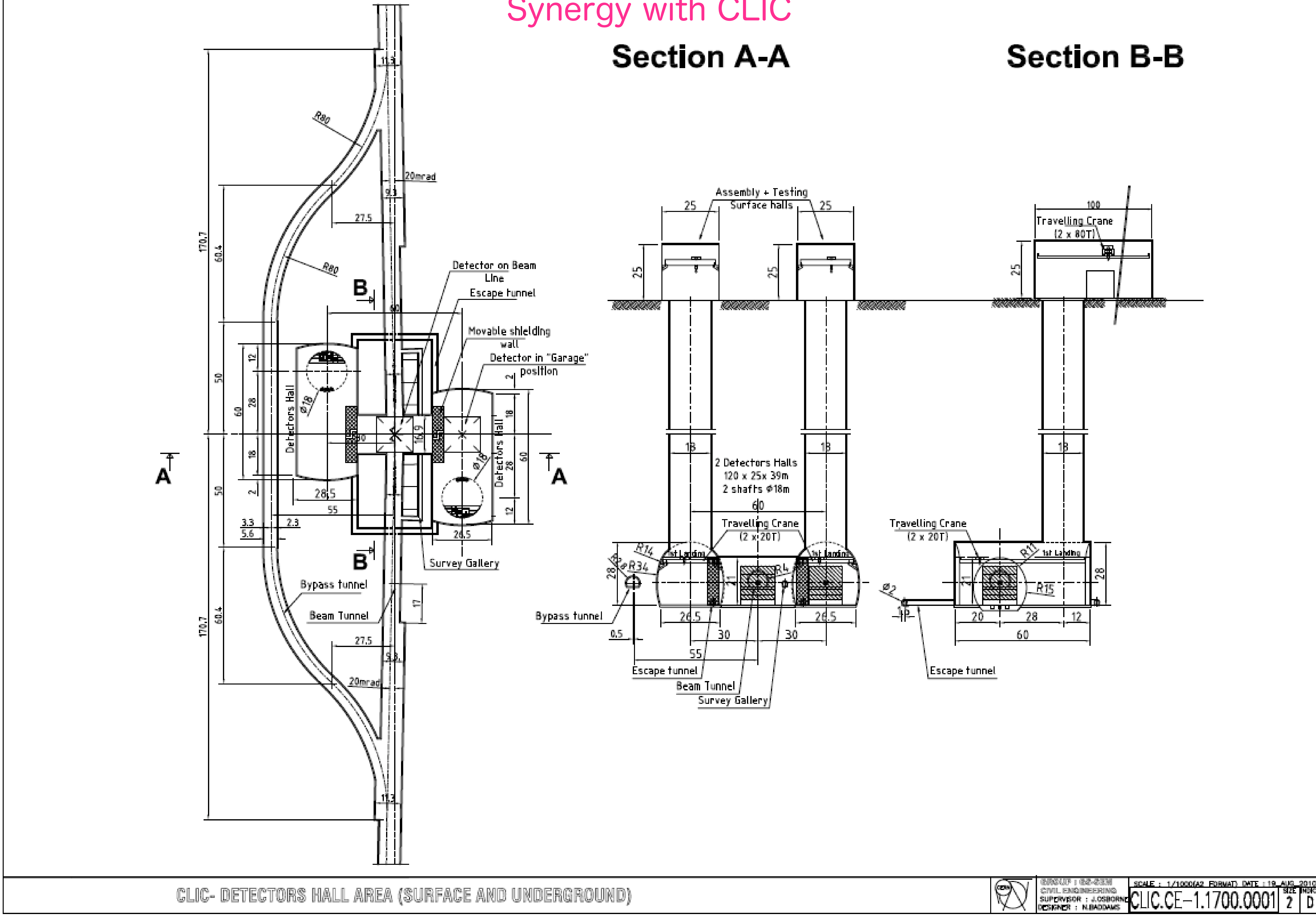
(with 2% damping factor)

H. Yamaoka, LCWS2010, Beijing, March 2010

QD0 recently updated by B.Parker (BNL)



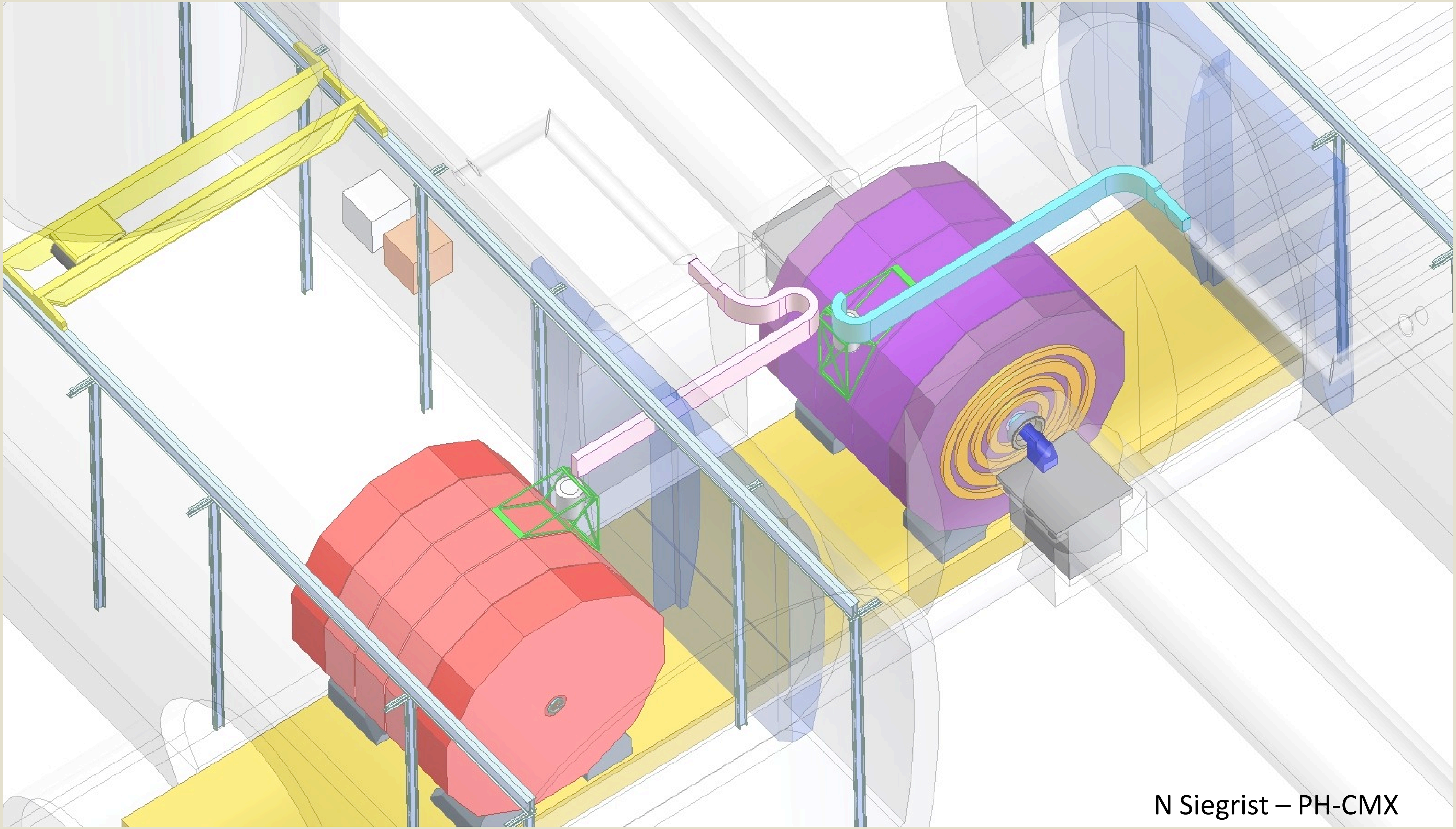
Synergy with CLIC



2011年 5月 20日 金曜日

Synergy with CLIC

The detector would be moved into beam position on a moving platform
The concept could be similar to the CMS PX56 plug (2200 tons)



Draft of “engineering specifications”, 20 May 2011

Engineering Specifications (1) : Push Pull Issues	unit	value	SiD	ILD
Time for Exchange experiments with rough alignment (mm)	day	1		
Time for Fine alignement, vacuum evacuation	day	1		
Time for Restart the machine and experiment	day	1		
Time for Beam calibration and alignment for the nominal luminosity	day	1		
Number of Pushpull operation	/year	10		10
Number of Pushpull operation for 15 years	times	150	100	150
Detector total weight	tons	15,000	10,000	15,000
Detector beam level	m	9	7.4	8
Maximum acceleration on the detectors during the movement	G	0.5	0.0001	
Total moving distance from IP to the garage position	m	15		25
Residual magnetic field at IP from detector in the garage	Gauss	50		50
Pulling forces with two lines (multiple anchoring points?)	tons/line	300		
Number of anchoring points		4		
Movement speed	cm/min	10	6	
Displacement due to the movement : radius	mm	20		
Displacement due to the movement : angle	mrad	2.5		
Adjustment of the movement : radius	mm	2		
Adjustment of the movement : angle	mrad	0.2		
Slow downward movement of the floor within ±50m around IP (for several weeks?) with feedback system	mm	5		
Platform : width	m		20	14
Platform : length	m		20	14.8
Platform : thickness	m		2.8	2.2
Platform : wall clearance	mm		10	
Platform : max. vibration transfer function for microseisms	$1<f<100$Hz		1.5	
Platform : pulling force in locomotion system with rollers	tons	750	500	750
Platform : pulling force in locomotion system with airpads	tons	300		300
Roller : a roller system must be supplemented by another system that allows a 3-axis movement on IP. A good candidate would be a grease-pad system on top of the roller supporting platform.				
Airpad : Standard airpad systems have the disadvantage of requiring a slight lift of the load of around 5 mm. However as the landing is obtained by leaking air through orifices this landing is very smooth as it had been verified by installing accelerometers on CMS elements.				
hydraulic jacks :				

Draft of “engineering specifications”, 20 May 2011

Engineering Specifications (2) : Experimetnal Hall	RDR	SiD	ILD	ILD in Mtn. site
Parameters that define the underground hall volume				
IR Hall Area(m) ; (W x L)	25x120			
Beam height above IR hall floor (m)	8.6	9(7.5)	8(9)	9
IR Hall Crane Maximum Hook Height Needed(m)	20.5	5m above top of detector	20.5	20.5
Largest Item to Lift in IR Hall (weight and dimensions)	400t	100t PACMAN	55t, 3x3x1.5m	400t
IR Hall Crane	400t+2*20t	100t/10t	80t	400t
IR Hall Crane Clearance Above Hook to the roof (m)	14.5(includes arch)		6	
Survice caverns(m) ; (W x L xH)	none			15x25x11
Resulted total size of the collider hall (W x L x H)	25x120x39	28x48x30		
Parameters that define dimensions of the IR hall shaft and the shaft crane				
Largest Item; Heaviest item to Lower Through IR Shaft (weight and dimensions)	9x16m, 2000t	600t	3411t, 15.7x8m (ring 2.7m thick)	-
IR Shaft Size : diameter(m)	16	9	16	-
IR shaft fixed surface gantry crane. If rented, duration	1.5 years	1.5 years	1.5 years	-
Surface hall crane should serve IR shaft	Yes	Yes	Yes	-
Other shafts near IR hall for access	No	Yes	No	-
Elevator and stares in collider hall shaft	Yes	?	Yes	
Size of access tunnel at Mtn. site (W x H, m)	-	-	-	11x11, 10.2x7.2
Parameters that define dimensions of the surface assembly building and its crane				
Surface Assembly Building Area ((W x L , m)	25 x 100		30x60	27x100
Largest Item to Lift in SurfAsm. Bldg. (weight and dimensions)	400t	70t	180t	180t
Surface Assembly Crane	400t+2*20t	100t/10t	2x80t	400t
SurfAsm. Crane Maximum Hook Height Needed(m)	18	20	19	25
SurfAsm. Crane Clearance Above Hook to the roof (m)	7		5m to ceiling	
Resulted volume of surface assembly building (W x L x H, m)	25 x 100 x 25		30x60x24	
Parameters that define crane access area and clearance around detector				
SurfAsm. crane accessible area (needed) / available (W x L, m)	20 x 102		28x56	
IR hall crane accessible area (needed) / available (W x L, m)	22 x 98		28x41	18x39
Maximum Detector Height(m)		16.15	15.74	15.74
Detector Width (m)		18.53(14.334)	15.665	15.665
Minimum Detector Clearance (W x L H, m)			15.67x13.26x15.74	15.67x13.26x15.74
FILL IN OTHER IMPORTANT PARAMETERS WHICH ARE MISSING				
Electronic hut size			18x9x10m	
Electronic hut location				
When the electronic hut is installed underground				

Draft of “engineering specifications”, 20 May 2011

Engineering Specifications (3) : QD0 Issues	unit	value	
Mover : number of degrees of freedom		5	horizontal x, vertical y, pitch φ, yaw ψ, roll α
Mover : Range per x,y degree of freedom	mm	± 2	
Mover : Range per φ, ψ degree of freedom	mrad	± 1	
Mover : Range per α degree of freedom	mrad	± 30	
Mover : Step size per degree of freedom of motion	μm	± 0.05	
Before BBA : Accuracy per x,y degree of freedom	μm	± 50	
Before BBA : Accuracy per φ, ψ degree of freedom	μrad	± 20	
Before BBA : Accuracy per α degree of freedom	mrad	± 20	
BBA : alignment accuracy per x,y	nm	± 200	from a line determined by QF1s for 200ms
BBA : Accuracy per α degree of freedom	μrad	± 0.1	from a line determined by QF1s for 200ms
Vibration stability : $\Delta(QD0(e^+)-QD0(e^-))$	nm	50	within 1ms long bunch train

Engineering Specifications (4) : Radiation shield	unit	value	
Self shielding		must	
Normal operation : anywhere beyond the 15m zone housing the off-beamline detector	μSv/hour	0.5	
Accidental beam loss : dose for occupational workers	mSv/hour	250	The acident is defined as the simultaneous loss of both e^+ and e^- beams at 250 GeV/beam anywhere, at maximum beam power.
Accidental beam loss : integrated doze for occupational workers	mSv/accident	1	
Accidental beam loss : beam shut-off time after the accident	beam-train	1	

Engineering Specifications (5) : Vacuum	unit	value	
in the 200m upstream of the IP	nTorr	1	$=1.3 \times 10^{-7}$ Pa
in the remainder of the BDS system	nTorr	10	$=1.3 \times 10^{-6}$ Pa
in the 18m zone of the detector			not specified in the IR document

Conclusions

- Platform system was chosen for the push pull operation at ALCPG11.
- MDI continues to study based on the work plan with milestones for the DBD/TDR and additional resources by the ILCSC.
- Draft of the engineering specifications was made for designs of the push-pull system and experimental hall with collaboration of the CFS group.
- We will enlarge the synergy with CLIC.